DOCTOR OF PHILOSOPHY

The Relationship between Socio-economic Status, Oral Health, Dental Services Uptake and the Provision of Dental Treatments amongst Adolescents

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The Relationship between Socio-economic Status, Oral Health, Dental Services Uptake and the Provision of Dental Treatments amongst Adolescents

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'The miracle is not that I finished, it's

that I had the courage to begin.'

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Abbreviations

BSO	Business Services Organisation (CSA prior to June 2009)
CI	Concentration index
CDS	Community dental service
CHIS	California Health Interview Survey
CSA	Central Services Agency (BSO from June 2009 onwards)
DMFT	Decayed, missing and filled teeth
GDS	General dental service
HRP	Household reference person (in a lone parent family this is the lone parent, in a couple family the reference person is chosen from the two people in the couple on the basis of their economic activity (in the priority order; full-time job, part-time job, unemployed, retired, other). If both people have the same economic activity, the reference person is taken as the older of the two or in the case of both being the same age, the first member of the couple listed on the form)
NHS	National Health Service
NISRA	Northern Ireland Statistics & Research Agency
NICE	National Institute for Clinical Excellence
NILS	Northern Ireland Longitudinal Study
NS-SEC	National Statistics Socio-economic Classification
RELP 1-6	Relationship of NILS member to other household members
SES	Socio-economic status
SDR	Statement of dental remuneration
WHO	World Health Organization
WTE	Whole time equivalent

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1 Introduction

1.1 Oral health in adolescents

Oral health was defined by the Department of health as the, 'standard of health of the oral and related tissues which enables an individual to eat, speak and socialise without active disease, discomfort or embarrassment and which contributes to general well-being' (1). As permanent teeth erupt just prior to or during adolescence, oral health will peak at this time when teeth are at their newest and least likely to be affected by decay. This stock of health is expected to depreciate across the years of life for a number of reasons relating to biological factors, social and physical environment, health influencing behaviours and dental care (2). In accordance with these factors, the rate of depreciation of oral health will therefore take place at faster rates for some groups than others.

The two most common oral diseases in adolescence are dental caries and periodontal disease both of which are likely to cause pain (3). The consequences of such pain will have an effect on adolescents and this may have life-long implications; for example lost school days (4) may affect the learning experience which in turn could negatively impact on examination performance and hence leave such adolescents at a disadvantage when entering the job market. Although no specific studies have been conducted, adolescents with poorer oral health will for obvious reasons be more likely to become edentulous later in life. Edentulous individuals, most likely due to difficulty in eating some foods, have been found at greater risk of malnutrition (5).

Aesthetic appearance of teeth may improve, through the use of orthodontic treatment, or deteriorate, with increased caries or periodontal disease, during adolescence and this can affect the way adolescents socialize (4). Adolescents whose teeth are less aesthetically appealing may be less likely to socialize as a result of bullying or low self esteem (4). Generally speaking, with poorer oral health, one is likely to experience a lower quality of life (6).

Adolescence presents a time when one is gaining independence from parental influences and adolescents are likely to have increased responsibility for their oral

health e.g. dental visiting (7). This makes oral health in adolescence even more challenging to sustain. Identifying those adolescents at the greatest risk of having the poorest levels of oral health will allow for appropriate measures to be designed and implemented in order to attenuate such disparities.

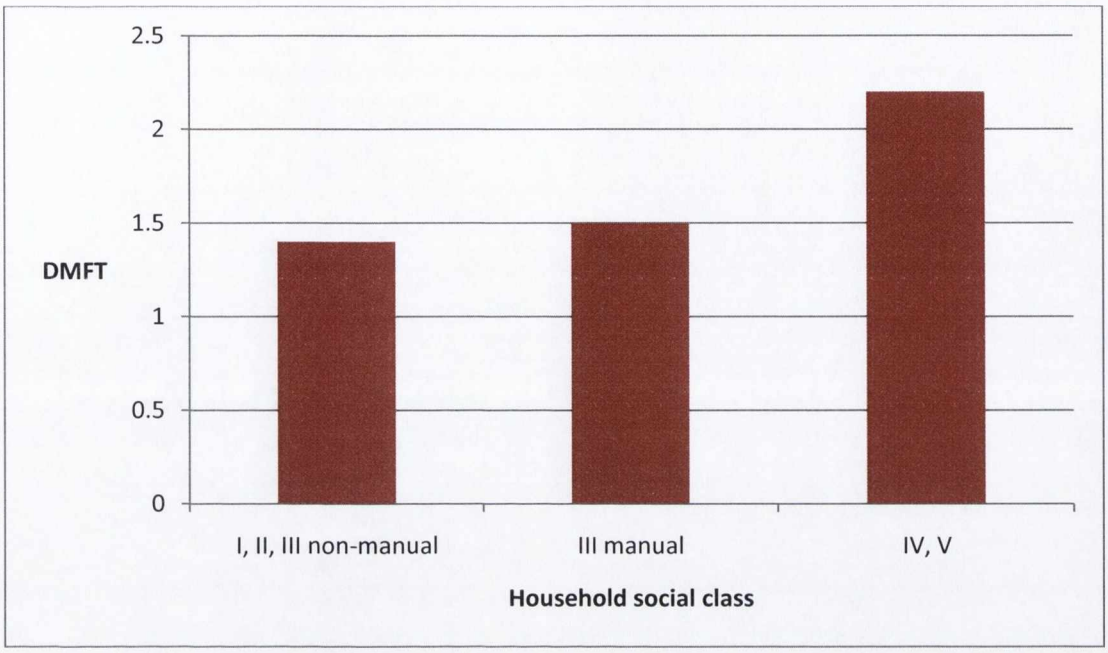
1.2 Oral health and SES

SES has been linked to health inequalities for many years whereby lower social classes display lower levels of health (8-10). A report by the World Health Organization in 2008 identified the extent of current national and international social gradients in health and made recommendations to address these inequalities (11).

Social inequalities are also witnessed in relation to oral health (12). A systematic review identified this relationship between SES and caries, a measure of oral health, to exist amongst adolescents (13). The 2003 Children's Dental Health Survey showed a social gradient in relation to DMFT amongst 15 year olds in the UK. The highest social groups had on average a DMFT score of 1.4 whereas the respective score for the lowest social groups was 2.2 (figure 1.1). This PhD will examine this relationship between oral health and SES in more detail (chapter 2).

A recent independent review was undertaken by Sir Michael Marmot, as requested by the Secretary of State for Health, into current inequalities in health (14). Within the review, inequalities in health were said to be socially unjust as there is an unfair distribution of health. The report also noted health inequalities have considerable costs to society as illness is expensive to treat and also has associated productivity losses. The review makes recommendations to deliver and monitor reductions in health inequalities along the social gradient. However, for such recommendations to be effective, there needs to be an understanding of the causes of social inequalities in health delivered through evidence based research. Such research in oral health amongst adolescents is currently lacking and is undertaken in chapter 3.

Figure 1.1: Mean DMFT by household social class (United Kingdom, 2003)

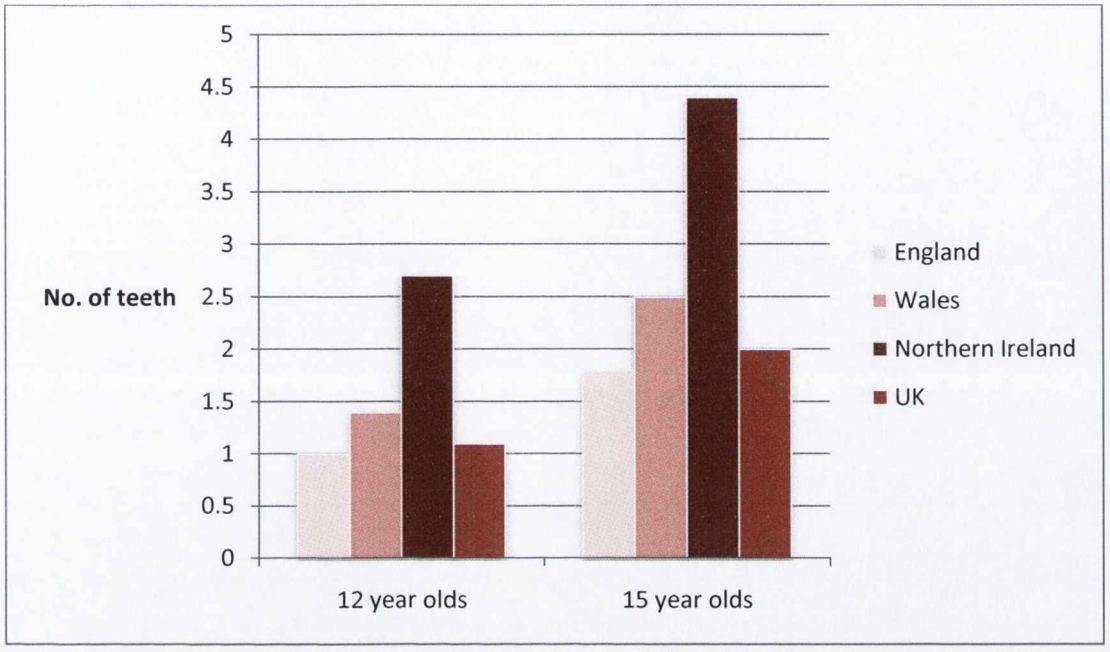


Source Children's Dental Health Survey 2003

1.3 Oral health in adolescents in Northern Ireland

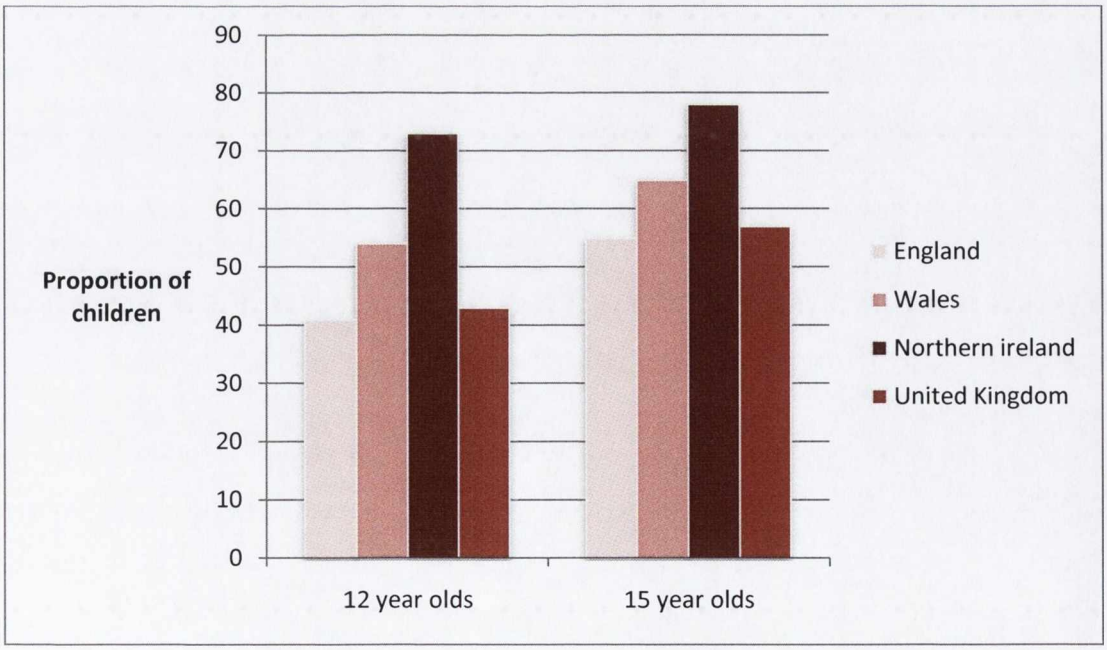
Within the UK, amongst adolescents, Northern Ireland has the poorest levels of oral health. Figure 1.2 shows the mean number of permanent teeth with obvious decay. For both 12 year olds and 15 year olds, the mean number of permanent teeth affected by decay is higher in Northern Ireland than across the UK; 2.7 teeth compared to 1.2 teeth for 12 year olds and 4.4 teeth compared to 2.0 teeth for 15 year olds. Figure 1.3 shows that the number of children with obvious decay in Northern Ireland is also higher than the UK; 78% compared to 57% for 15 year olds and 73% compared to 57% for 15 year olds.

Figure 1.2: Mean number of permanent teeth with obvious decay experience by country and age (United Kingdom, 2003)



Source Children's Dental Health Survey 2003

Figure 1.3: Proportion of children with obvious decay experience in permanent teeth by country and age (United Kingdom, 2003)



Source Children's Dental Health Survey 2003

The poorer state of oral health in Northern Ireland is thought to be partly attributed to an unfluoridated water supply. Unlike Northern Ireland, parts of the rest of the UK and also the Republic of Ireland benefit from a fluoridated water supply. Material deprivation amongst the Northern Ireland population is also thought to contribute to the poorer oral health witnessed as unhealthy behaviours associated with deprivation cause poorer oral health (15). Northern Ireland is the most materially deprived part of the UK with the lowest average weekly household income (16).

In addition to a high level of deprivation in Northern Ireland, marked inequalities exist in the distribution of wealth. The Gini coefficient places Northern Ireland amongst the least economically equitable countries in Western Europe (16). Unequal distribution of wealth within societies is thought to contribute to poorer health (17). This combination of poor oral health and inequity in the distribution of resources gives good reason to investigate social inequalities in oral health in Northern Ireland including how this may interact with dental healthcare.

1.4 Dental health services

Regular use of dental health services is one way of maintaining oral health. The dentist is afforded an opportunity to prevent disease and treat early. Within the UK, dental treatment is provided free of charge to all adolescents. Dentists are reimbursed on a fee for item of service which therefore means all treatments carried out by dentists generate income. Efficiency in the use of dental healthcare resources requires these resources are employed in a way that ensures the greatest impact on health is obtained.

The NHS aims to promote equal access for equal need within healthcare provision (18). Access to NHS dental care is available to those registered with an NHS dentist. A study amongst children in England identified an inverse dental care law whereby the most socially deprived were the least likely to be registered with a dentist(19). As discussed above, it is the most socially deprived who are likely to be in the greatest need of dental healthcare. A previous study also identified inequalities existed in the

dental treatment provided to children within the UK according to SES (20). A deeper understanding of dental registration and provision of dental treatments is required.

1.5 Aims and structure of the thesis

The aims of this thesis are:

1. To identify the nature and strength of the relationship between SES and oral health amongst adolescents in the UK

2. To identify what the underlying causes of any relationship found between SES and oral health amongst adolescents may be

3. To explore and explain, within an economic framework, variations in the registration for dental services according to SES (other factors controlled for)

4. To explore and explain, within an economic framework, variations in the intensity of use of dental treatments according to SES (other factors controlled for)

The thesis continues as follows: in **Chapter 2** a systematic review of the relationship between SES and oral health amongst adolescents within the UK is presented. This addresses the first aim of the thesis and looks at a range of oral health measures: caries (and elements of caries), periodontal disease, dental trauma and orthodontic need.

Chapter 3 explores the relationship between SES and self-reported oral health amongst adolescents in California using the CHIS 2007. This chapter uses a model of the determinants of oral health, the Fisher-Owens model, to determine the underlying factors of SES inequalities in oral health.

Chapter 4 discusses epidemiological studies which have investigated dental services utilisation.

Chapter 5 describes the economic models which have been developed to explain the demand for health. One of the most influential models in this area is the Grossman Human Capital Model of the Demand for Health (21). An economic model to explain investment in dental health amongst adolescents is developed.

Chapter 6 describes the unique dataset which was created to test the economic model developed in chapter 4. The procedures which had to be undertaken to create and allow access to this dataset are also documented. Statistical methods used to analyse the dataset are described.

Chapter 7 presents an empirical analysis of the model developed in chapter 4 using the dataset described in chapter 6. Registration for dental services is used as the outcome variable.

Chapter 8 presents an empirical investigation of the model developed in chapter 4 using once again the dataset described in chapter 5. Expenditure and intensity of dental treatments within the NHS are used as outcome variables.

Chapter 9 discusses the findings of this PhD and the implications for health care policy. Strengths and limitations of the linked dataset are also discussed. The thesis is then concluded.

2 The relationship between socio-economic status and oral health amongst adolescents in the UK: a systematic review of the evidence base

2.1 Introduction

The existence of a social gradient in health is well documented (22, 23) as is the fact that this relationship extends to oral health (12). Also evident from the literature on this subject is that the nature of the relationship between oral health and SES has changed over time as well as varying between age groups at the same point in time. While, for example, surveys in Britain revealed a positive relationship between prevalence of caries (decayed, missing due to decay and filled teeth) and SES amongst children between the late nineteenth and mid-twentieth century (24, 25), by the late twentieth century an inverse relationship was observed amongst twelve and fifteen year olds (26).

SES is a multidimensional construct comprised to describe the social and economic environment within which one lives. It is expected to be an indicator of economic resources available, power which the individual has and level of prestige. Despite SES being complex and multifactorial, it is often represented by a single socioeconomic variable (27). SES can be an individual based measure or an area based one with the former generally being regarded as superior (28, 29) but not always available. SES measures which are area based have been found subject to ecological fallacy, a fallacy inherent from making causal inferences from group data to individual behaviours or outcomes (30, 31). Individual based measures of SES within Europe usually relate to occupation (32-34). In order to guage SES relating to a child, although some studies will use occupation of the father, the general consensus is that occupation of the principal earner within the household should be used (35).

The relationship between SES and caries prevalence is one example of the relationship between SES and oral health. It is likely explained by a combination of factors including access to dental services, the provision of public health measures (such as fluoridation of water supply) and the choices individuals make affecting their exposure to risk (such as sugar consumption or oral hygiene habits). Among minors, adolescents are likely to exhibit the greatest autonomy in terms of individual

choices as during this period of life one develops independence from parents and guardians. These choices as well as access to dental services may relate to underlying socio-economic variables making the relationship between social class and oral health among adolescents of particular interest.

A recent systematic review (13) identified an inverse relationship between SES and the prevalence of caries among adolescents. However, this review was conducted worldwide which involves many different health systems. This is a systematic review of the literature that has examined the relationship between SES and oral health amongst adolescents in the UK.

2.2 Methods

2.2.1 Search strategy

A number of electronic bibliographic databases (Medline, Embase, Cochrane and the National Research Register) were searched. The search included peer reviewed journal papers written between January 1980 and March 2008 and was restricted to the English language only. The UK National Children's Dental Health surveys conducted during this period were also included among the material examined. The search terms used can be found in appendix 1. Citation lists from included references were examined to identify additional relevant studies.

2.2.2 Study selection

The following criteria were used to sift papers for inclusion in the review:
Study design: Studies that used any comparative design in the statistical analysis of original data were included in the review
Population: Studies that reported on adolescents, aged 10 – 19 years (consistent with the World Health Organization definition of adolescence (36)). Studies that might have included adolescence but where the relationship specifically relating to adolescence could not be discerned were excluded
Outcome: Studies that reported on any measure of oral health from among the following: caries, tooth surface loss, periodontal disease, trauma or orthodontic need, were included in the review. Other aspects of oral health such as oral cancer were

deemed too uncommon within this age group and were therefore not included in the review

Exposure/ variable: Studies that reported on any commonly used measure of social status (area, individual level or school attended) were included in the review

Area: To avoid the potentially complicating influence of differing health care systems upon the relationships between oral health and SES, only studies relating to the United Kingdom were included in the review

Language: The review was confined to papers written in English

Finally, given changes in the relationship between SES and oral health, during the 20th century, it was decided to restrict the review to those which reported on data collected from the period January 1980 onwards. This was done to increase the relevance of the review's findings to current circumstances. Studies returned via the search methods were simultaneously sifted by two reviewers (Claire Telford and Ciaran O'Neill) using these criteria. All disagreements were resolved by discussion and without having to consult a third party.

2.2.3 Assessment and reporting of study quality

The quality of included studies was assessed using the authors' own scale (see appendix 2). This assessment was based on a number of factors including study design, study size, selection and recruitment procedures, response rates, procedures employed to control for potential confounding, methods and reliability of outcome assessments and follow-up rates (where applicable). Regarding the overall quality of the studies included in the review, no attempt was made to construct a formal cardinal assessment of quality. Rather, the criteria identified were used to form an assessment of quality relative to other studies.

2.2.4 Data extraction and synthesis

Data extraction was undertaken using a pre-designed data extraction form. Although some of the studies reported on multiple oral health measures, only those measures as identified above listed in relation to SES were used in this review.

Data synthesis using a formal statistical meta-analysis was not deemed appropriate for this review because of substantial heterogeneity in both the exposure and the outcomes of interest. For example, this review looked at five broad oral health measures; dental caries, tooth surface loss, periodontal disease, dental trauma and orthodontic need; there exists within each, various ways in which oral health may be measured. Taking periodontal disease for example, it is measured inter alia; mean (mm) amelo-cemental junction to alveolar crest distance, pocketing, bleeding and community index periodontal treatment need (CIPTN), with only a few studies existing in each area. This is similarly the case in respect of social class, where measures also vary greatly with individual measures used including social class based on occupation of head of household, school attended and area based measures such as ACORN, Carstairs and the Jarman Indices. Instead of a meta-analysis, the relationships found within each of the twenty seven studies have been reported on within tables 2.3 and 2.4. In addition to this, it was possible to show DMFT in relation to SES as measured by occupation of head of household and how this has varied between social classes and across time (figure 2.2 and figure 2.3). Unfortunately no other oral health measure provided enough studies with the same oral and SES measures to be reported on in this way.

2.3 Results

2.3.1 Studies identified

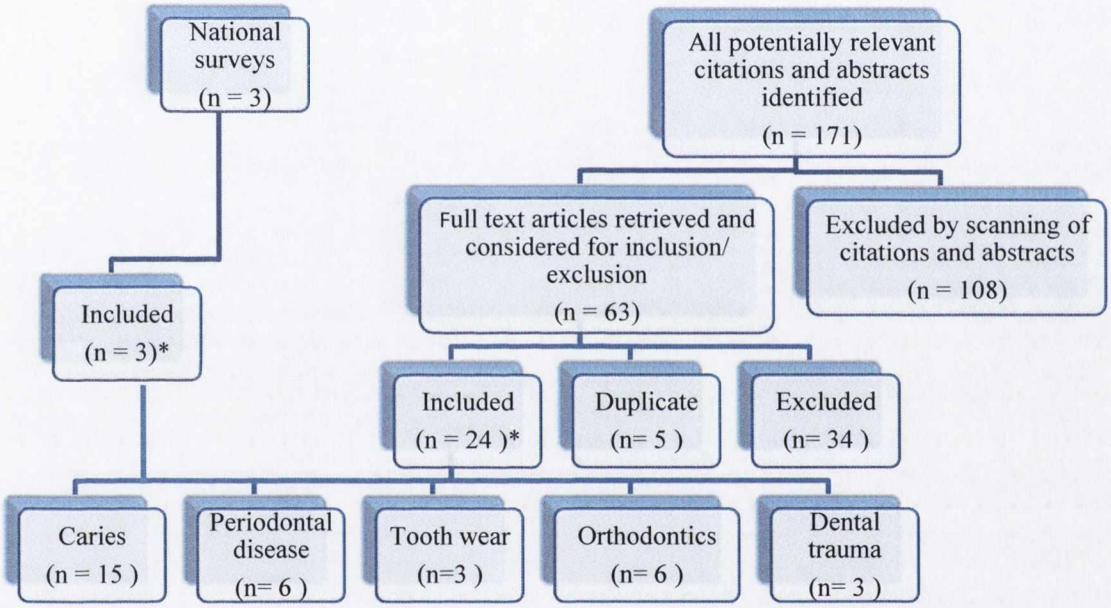
The search of the databases returned one hundred and seventy one potentially relevant studies. From this, one hundred and eight were considered not to be relevant based upon an examination of titles and abstracts and were excluded from the review.

For the remaining sixty three citations and abstracts, the full text was retrieved and considered for the review. Five duplicate studies were excluded. A further thirty four were excluded; thirteen because adolescents were not included or the data was not presented separately for this age group; fourteen because social status was not presented with an oral health measure used in this review; five because statistical significance tests were not conducted, one because the SES measure was not

commonly used (based on social readership) and one because the data was collected prior to 1980. Twenty four studies were included from the database search.
The search of UK National studies returned three prospective studies (1983, 1993 & 2003), all of which met the required inclusion criteria and were subsequently included.

Figure 2.1 shows the process by which the studies founding the search were sifted.

Figure 2.1: Identified studies



*Caries, periodontal disease, orthodontics, tooth wear and dental trauma sum to thirty three as, three of the studies included both periodontal disease and caries while a further study included all measures except dental trauma

2.3.2 Characteristics of included studies

Table 2.1 presents an outline of the twenty seven included studies, this includes the author and country where the study was conducted, type of study, date of data collection with any associated follow up, the age characteristics of the population studied, the social status measure and the reported oral health outcome (only those given alongside social status are reported).

2.3.3 Quality of evidence

Included studies comprised twenty-four cross sectional (one of which being repeated cross sectional) and three prospective cohort studies. As mentioned earlier quality of included studies was assessed using the authors' own scale (appendix 2) this was done by Claire Telford and the results are presented in table 2.2 below. Overall large sample sizes were used. The recruitment was mostly through random selection and twenty of the studies had a response rate greater than or equal to 60%. Eight of the studies controlled for both age and gender in the sampling methodology or analysis, with the remaining nineteen controlling for age only.

Twenty-five of the studies used a clinical examination and of these nineteen assessed and reported the examiners' reliability. For the three cohort studies, one study (37) had a follow-up greater than or equal to 80%, one study (38) a follow-up between 60% and 79% while the remaining study (39) had a follow-up between 50% and 59% but kept the same SES structure between baseline and follow-up and does therefore not question the study's validity.

Within the context in which the studies were conducted, most were deemed to be of a reasonable quality. Eleven studies (26, 38-47) were deemed to be of the highest quality (these lie in the shaded rows of table 2.2) due to the use of validated, individual measures being used for the exposure (SES). These eleven studies coincidentally all used occupation of head of household to measure the exposure (SES) and had no underlying quality issues. All studies met the minimum requirements for quality and will be discussed, however, they will be discussed separately to the eleven studies previously mentioned.

2.3.4 Outcomes

As discussed above, the outcomes of this review have been divided into two separate tables. Table 2.3 reports on the relationship between each oral health measure and SES as measured by the occupation of head of household as this measure is an individual, validated measure of SES, while table 2.4 reports on the relationship were SES as measured by the area in which the adolescent lived or the school they attended.

2.3.4.1 Caries

Of the studies that used occupation of head of household measures for SES, five studies (26, 42, 44, 45, 47) identified an inverse relationship with Caries (DMFT or DMFS), that is, lower social classes had greater caries severity. The 2003 national survey (46) found mixed results. With reference to the percentage of children with caries and caries severity, a relationship was found amongst 15 year olds but not 12 year olds. A further study (40) found no relationship when looking at the proportion of 14 year olds children with caries. Figure 2.2 below shows the DMFT score according to SES for 11-14 year olds for five of the six studies (it was not possible to graph the remaining study as no DMFT scores were provided). Whilst two of the studies were conducted within particular areas (Wales and Scotland), the remaining three studies are UK national studies. These national studies show a decline in DMFT of approximately 2.0 across all social classes during the 20 year time period spanning from 1983 – 2003. Figure 2.3 shows the DMFT score according to SES for 15-16 yr olds, with three of the four studies being UK National Studies. Again, within this age group a decline in DMFT has been witnessed for each social class across the 20 year time period however, this time the declines are much greater, ranging from 4.4 in the middle social class to 3.8 in the highest social class. From looking at these national surveys we can conclude DMFT has fallen within each social class. Also evident is, although in the past there have been significant differences between social classes, the latest findings show a loss of this significance when looking at DMFT severity or proportion of children with caries amongst 12 year olds but there is still a clear social gradient amongst 15 year olds. The 2003 UK national survey found, amongst 15 year olds, 65% from the lowest social class to have caries experience compared to 47% from the highest social class.

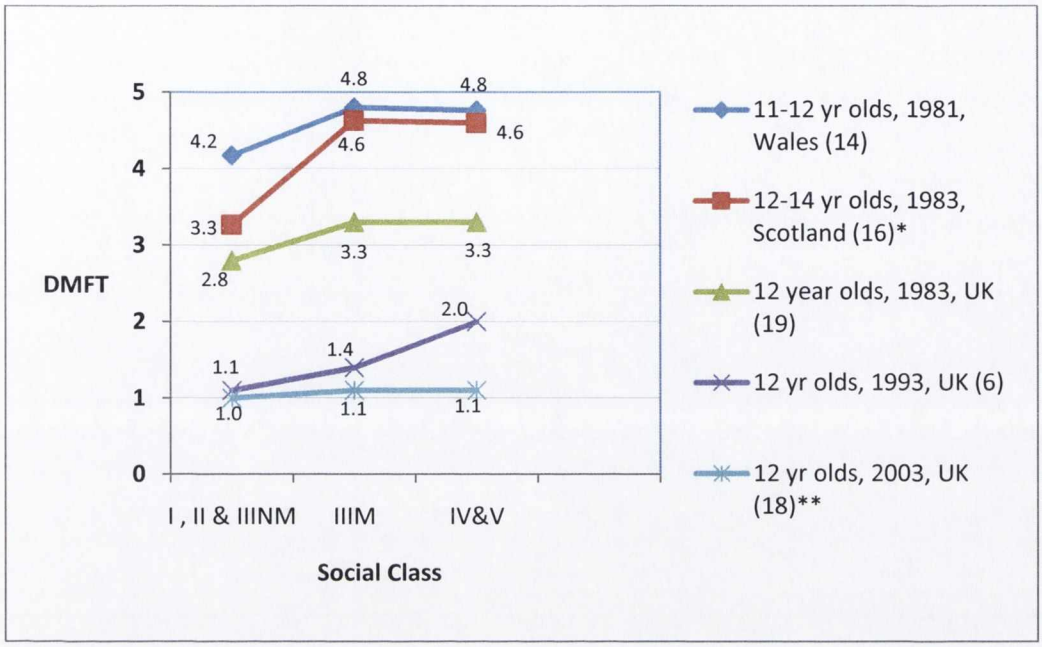
Two studies (26, 40) found lower social classes to have more adolescents with untreated decay while one study (46) found this relationship to exist amongst 15 year olds but not 12 year olds. Two studies (26, 43) found adolescents from lower social classes to have greater levels of untreated decay. These findings support the contention that by mid adolescence untreated decay levels are higher amongst those in lower social classes. The 2003 UK national survey found, amongst 15 year olds, 33% from the lowest social class to have untreated decay, compared to 23% from the highest social class.

The 1993 national survey (26) and a further study (40) found a greater proportion of children from lower social classes to have missing teeth due to decay whereas the 2003 national survey found this was the case for 15 year olds but not 12 year olds. This evidence suggests by 14 or 15 years old, lower social classes are more likely to have lost teeth due to decay. The 2003 UK national survey found, amongst 15 year olds, 7% from the lowest social class had lost teeth due to decay compared to 2% from the highest social class.

Two studies investigating the proportion of adolescents with fillings found differing results; the 1993 national survey (26) found those in lower social classes more likely to have fillings while another study (40) found no relationship. The former of the two previous studies also found the number of fillings to be significantly greater in lower social classes.

Looking at table 2.4, which presents the results when school attended or area based measures were used as a proxy for SES, shows similar results for caries or caries related measures. The 2003 national survey found once again, at 15 years old, lower social classes had a greater percentage of adolescents with decayed teeth and missing teeth but this relationship was now also evident amongst 12 year olds.

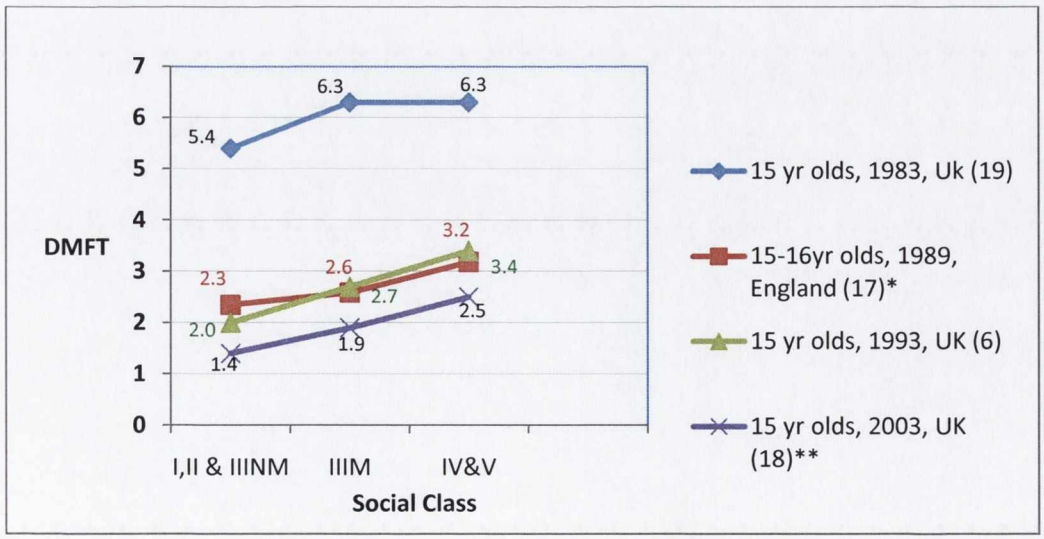
Figure 2.2: Mean DMFT by SES (head household) 11-14 yr olds



* Reports on IIINM & M together as middle social class

**In the 2003 national survey, the criteria for assessing DMFT were changed from those in earlier surveys and social class assessed by NS-SEC

Figure 2.3: DMFT by SES (head household) 15-16 yr olds



* Reports on IIINM & M together as middle social class

**In the 2003 national survey, the criteria for assessing DMFT were changed from those in earlier surveys and social class assessed by NS-SEC

2.3.4.2 Tooth wear/ erosion

The 2003 national survey was the only study to look at SES as measured by occupation of head of household and found no relationship with the percentage of adolescents displaying tooth wear/ erosion.

Using area or school attended to measure SES presented a mixture of results; two studies found lower social classes more likely to have tooth erosion, one study found the opposite while another study found no relationship. This leaves the relationship between tooth wear/ erosion and SES rather ambiguous.

2.3.4.3 Periodontal disease

Of the studies to examine the relationship between periodontal disease and SES as measured by occupation of head of household, two studies (41, 42) (carried out in 1980's) found evidence that lower social classes have on average higher levels and are also more likely to show signs of periodontal disease. The 2003 national survey (looking at SES as measured by both occupation of head of household and school attended) however shows evidence that these relationships no longer exist. This evidence suggests lower social classes displayed higher levels of periodontal disease in the 1980's but this is no longer the case.

2.3.4.4 Dental trauma

There were no studies which looked at SES as measured by head of household and dental trauma. Three separate studies on 14 year olds in England during the 1990's found mixed results regarding area based SES and traumatic dental injuries. One study (48) found a greater proportion of adolescents from lower social classes showed signs of dental trauma whereas two other studies (49, 50) found no such relationship. It can therefore not be concluded a relationship exists between SES and dental trauma.

2.3.4.5 Orthodontics

The Index of treatment need (IOTN) is one such measure used to measure orthodontic need. The 2003 national survey identified that amongst 15 year olds

unmet need was greater in lower social classes; this relationship was however not identified amongst 12 year olds. Another study (39) conducted amongst 11/12 year olds in 1981 found no relationship between SES and unmet orthodontic need.

When the proxy for SES was area based or school attended, a majority of the studies revealed no relationship between SES and unmet orthodontic need. However, the 2003 national survey, using school attended as a proxy for SES, found results consistent with those for SES as measured by occupation of head of household, the relationship existed amongst 15 year olds but not amongst 12 year olds. Going by the most robust study which exists (the 2003 national survey) would conclude there is a social gradient with respect to unmet orthodontic need by mid adolescence.

2.4 Discussion

This review has provided an overview of the studies which have carried out comparative analyses on socio-economic differences in oral health amongst adolescents within the UK. The review shows that despite a fall in the prevalence of caries between 1983 & 2003, a statistically significant social gradient still exists with respect to the proportion of adolescents who have caries, and caries severity amongst 15 year olds but not amongst 12 year olds. The review also shows that by mid-adolescence, a higher proportion of adolescents amongst lower social groups have untreated decay or missing teeth due to decay. Inverse associations between SES and periodontal disease seen in the 1980's no longer exist. There is no clear relationship between SES and dental trauma or tooth wear/ erosion which is in contrast to the social gradient with respect to unmet orthodontic need by mid adolescence.

With respect to dental caries, the fact that each social class has seen a definite fall across the time period 1983- 2003, and that amongst 12 year olds, both the proportion of children with caries and caries severity is no longer significantly different between social classes suggests we are moving towards achieving equity in oral health.

The fall in caries must, at least in part, be due to a greater availability of fluoride from toothpaste and our water supply. However by mid adolescence those from lower social classes are more likely to have caries, greater severity of caries, untreated decay or missing teeth due to decay. A variety of explanations, as noted, can be offered to explain this social gradient. The Black report (9) proposed one explanation for the observed association between social status and health may be 'to a large extent cultural influences shape health-damaging and health-promoting behaviour through processes of socialization that are socially graded.' Studies in the UK have shown those in higher social classes are more likely to have good oral hygiene habits (51), to attend a dentist more regularly (52, 53) and to spend significantly less on sweet consumption (42) than those in lower social classes. That oral health among those in lower social classes will suffer as a consequence is perhaps to be expected. The development of the social gradient by mid adolescence can be explained in that older adolescents have had a longer period of time in which to expose their permanent teeth to these hygiene habits and risk factors.

The materialist or structuralist explanation offered by Black may further explain the observed social gradient in respect of particular aspects of oral health. This explanation cites that income determines living conditions and circumstances and not only does this affect the exposed people but also their offspring. It may be that those from lower social classes are less able to change tooth brushes with the requisite frequency, use fluoride tooth paste, mouth wash or floss.

Also, it has been noted lower social classes within the UK have lower levels of dental utilization (54) and are less likely to be registered with a dentist (19), even though dental treatment is free of charge to all adolescents within the UK. A study conducted amongst adults found lower levels of oral health, as measured by sound teeth, amongst those of lower SES and that this association was partially explained by lower dental attendance as a result of barriers (55). Amongst adolescents although dental treatment is free of charge, there will be costs incurred with dental visiting relating to travel. A further barrier which may exist within adolescence relates to a parental time/ working arrangements; it may be easier for higher SES parents to find time to accompany children to a dentist due to more flexible working arrangements. In respect of caries, higher levels of dental utilization amongst higher social classes

may explain not only why measures such as DMFT were higher among those in lower social classes but why, in the study (40) where overall DMFT was not significantly higher among lower social classes, untreated decay was higher (thus, if the dentist is not afforded an opportunity to treat decay for whatever reason among those in lower social classes, it is perhaps unsurprising that epidemiological studies would find a greater level of untreated decay). This may also explain the social gradient with respect to unmet orthodontic need, as such need is assessed by the dentist, non-attendance or irregular attendance at a dentist will provide fewer opportunities for this need to be identified. In addition to this, those of lower SES identified with a need for orthodontics are less likely to seek treatment (39, 56).

2.5 Conclusions

This review has found caries levels have decreased across all social groups. Amongst 12 year olds, both the proportion of adolescents with caries and caries severity is no longer related to SES. In addition, periodontal disease appears to no longer be related to SES. These two findings indicate we are working towards equity in health as discussed by the Black Report (9) (1980) and the Acheson Report (10) (1998).

However, the latest literature suggests by mid adolescence those from lower social classes are more likely to exhibit caries, higher levels of caries, and individual components of caries; teeth with untreated decay and missing teeth due to decay. This is of great concern considering the ongoing research between oral health and overall health. The first Surgeon General's report issued in the USA in 2000, addressed the consequences of poor oral health in children, "if left untreated the patient could develop more serious and painful diseases and suffer from poor self esteem in regard to perceived poor appearance due to dental disease." The report also discusses the possibility of dangerous bacteria resulting from oral disease entering a patient's blood stream. In 2007 a World Health Assembly resolution called for oral health to be integrated into chronic disease prevention programmes (57). Oral diseases and chronic diseases such as cardiovascular disease, cancer, chronic respiratory disease and diabetes share many common risk factors.

In addition to the findings those from lower social classes are more likely to exhibit caries and individual components of caries, this review also found greater unmet orthodontic need amongst lower social classes, leading one to question the equity in access to and uptake of dental treatment. One way of measuring access to dental services is to look at dental registration, if adolescents are registered with a dentist, they will have access to treatment. The relationship between dental registration and SES will be investigated within this PhD.

What factors underlie such relationships are clearly worth investigation. A fuller understanding of these issues could identify not just where health inequalities are most stark but how best, policy measures could be devised to address them.

Table 2.1: Key characteristics of included studies

Authors Country Study Design	-Year of data collection (if not available publication year (PY)) -Follow up (if applicable)	Population Characteristics -baseline -follow-up	Socio-economic status measure	Outcome reported (in relation to social measure)
AL-Dlaigan et al[58] England Cross sectional	-2001(PY) -n/a	-14 yr olds -n/a	ACORN	Modified version of toothwear index[a]
Bardsley et al[59] England Cross sectional	- 1999 -n/a	-14 yr olds -n/a	Townsend	Modified version of toothwear index[a]
Bedi et al[40] Scotland Cross sectional	-1989-1990 -n/a	-14 yr olds -n/a	Registrar general's classification, HMSO 1980	DT, MT, FT, DMFT[b]
Bedi et al[41] Scotland Cross sectional	- 1989- 1990 -n/a	-14 yr olds -n/a	Registrar general's classification, HMSO 1980	Community periodontal index of treatment need (CPITN)
Booth & Ashley[60] England Cross sectional	-1985 -n/a	-15-17 yr olds -n/a	ACORN	DMFT,FT, Periodontal assessment[b] including: Plaque[c], Pockets[d], Gingivitis, Subgingival calculus
Burden et al[61] England Cross sectional	-1994(PY) -n/a	-15/16 yr olds -n/a	ACORN	Orthodontic need by IOTN(DHC&AC)[e]
Chestnutt et al[62] UK Cross sectional	-2003 -n/a	-12 & 15 year olds -n/a	School attended	Modified IOTN (DHC&AC)[e]
Dummer et al[42] Wales Cross sectional	-1981 -n/a	-11/12 yr olds -n/a	Registrar general's classification, HMSO 1980	DMFT[f], DMFS, DFS, plaque, bleeding, pocketing
Dummer et al[38] Wales Prospective cohort	-1981 -1984	-11/12 yr olds -15/16 yr olds	Registrar general's classification, HMSO 1980	Mean (mm) amelo-cemntal junction to alveolar crest distance
Ellwood and O'Mullane[63] England Cross sectional	-1995(PY) -n/a	-13/14 yr olds -n/a	Townsend	DMFS

Hamilton et al[37] England Prospective cohort	-1990 -1991	-11-14 yr olds -n/a	ACORN	Oral trauma (inside the 15 month period)
Jones et al[48] England Cross sectional	-1995 -n/a	-14 yr olds -n/a	Jarman	DMFT[g]
Jones et al[64] Scotland Cross sectional	-1992-1993 & 1994-1995 -n/a	-12 & 14 yr olds -n/a	Carstairs	DMFT[g]
Kenealy et al[39] Wales Prospective cohort	-1981 -1984	-11/12 yr olds -14/15 yr olds	Registrar general's classification, HMSO 1980	Orthodontic need(as measured by visible irregularity)[e]
Kinirons and Stewart[43] Northern Ireland Cross sectional	-1997(PY) -n/a	-14/15 yr olds -n/a	Registrar general's classification, HMSO 1980	D and D/DMFT[g]
Mandall et al[65] Manchester Cross sectional	-1999(PY) -n/a	-14/15 yr olds -n/a	Townsend score	IOTN(AC)[e] IOTN(DHC)[e]
Mandall et al[66] England Cross sectional	-1998(PY) -n/a	-14/15 yr olds -n/a	Townsend	DT[g], CPITN
Mansbridge and Brown[44] Scotland Repeated cross sectional	-1959 -1983	-14 yr olds -12-14 yr olds	Registrar general's classification of Occupation 1959	DMFT
Marcenes and Murray[49] England Cross sectional	-1995-1996 -1998-1999	-14 yr olds -14 yr olds	Jarman Index	Traumatic dental injuries
Milosevic et al[67] England Cross sectional	-1991 -n/a	-14 yr olds -n/a	Jarman score of school	DMFS (TWI criteria)
Murray et al[45] England Cross sectional	-1989-1990 -n/a	-15/16 yr olds -n/a	Registrar general's classification, HMSO 1980	DMFT[g]
O'Brien[26] United Kingdom Cross sectional	-1993	-12 & 15 yr olds	Registrar general's classification of Occupations	DMFT, DT, FT, MT
Pitts[68] Scotland Cross sectional	-1996-1997 -n/a	-12 yr olds -n/a	Carstairs	DMFT

Rodd and Chesham[50] England Cross sectional	-1994 -n/a	-14/15 yr olds -n/a	School attended[h]	Oral trauma
Steele and Lader[46] United Kingdom Cross sectional	-2003	- 12 & 15 yr olds	School attended National Statistics Socio-economic Classification (NS-SEC)	DMFT, DT, MT, inflammation, plaque, gingivitis, tooth surface loss, simplified index of orthodontic treatment need[e]
Tickle et al[69] England Cross sectional	-1994-1995 -n/a	-14 yr olds -n/a	Super profiles geodemographic classification	IOTN(DHC)[e]
Todd and Dodd[47] United Kingdom Cross sectional	-1983	- 12 & 15 yr olds	Registrar general's classification, HMSO 1980	DMFT

[a] Smith and Knight. An index for measuring the wear of teeth. BR Dent J 1984; 156:435-438

[b] WHO, Ainamo et al 1982

[c] Silness & Loe, 1964

[d] Hu-Friedy PQW

[e] Refers to unmet orthodontic need

[f] Downer 1975

[g] According to BASCD

[h] As self stated in the study, the validity of the approach adopted to classify socio-economic status, whereby school attended reflects geographical distribution of children, may represent a methodological problem as the Sheffield Education Committee operates a system where parents can choose a school outside their catchment area

Table 2.2: Methodological quality of included studies

		Selection and recruitment		Comparability			Assessment & reliability	
Study	**Sample size**	**Recruitment**	**Response**	**Control age & gender**	**SES measure**	**Validated exposure measure**	**Reliability**	**Follow-up**
AL-Dlaigan et al[58]	418	random	good	yes	area	yes	assessed & reported	n/a
Bardsley et al[59]	2351	random	not reported	age	area	yes	assessed & reported	n/a
Bedi et al[40]	1237	random	good	yes	individual	yes	assessed & reported	n/a
Bedi et al[41]	1237	random	good	yes	individual	yes	not reported	n/a
Booth & Ashley[60]	477	not reported	excellent	yes	area	yes	assessed & reported	n/a
Burden et al[61]	540	random	not reported	age	area	yes	assessed & reported	n/a
Chestnut et al[62]	4737	random	good	age	school attended	no	assessed & reported	n/a
Dummer et al[42]	1015	random	good	age	individual	yes	assessed & reported	n/a
Dummer et al[38]	1021	not reported	not reported	yes	individual	yes	assessed & reported	good
Ellwood and O'Mullane[63]	507	other, well described	excellent	age	area	yes	assessed & reported	n/a
Hamilton et al[37]	2022	full popln	good	age	area	yes	assessed & reported	excellent
Jones et al[48]	6014	random	not reported	age	area	yes	not reported	n/a
Jones et al[64]	17271	random	not reported	age	area	yes	n/a	n/a
Kenealy et al[39]	1018	random	excellent	age	individual	yes	assessed but not reported	fair
Kinirons and Stewart[43]	470	random	good	age	individual	yes	assessed but not reported	n/a
Mandall et al[65]	434	random	good	yes	area	yes	assessed & reported	n/a
Mandall et al[66]	408	random	good	age	area	yes	assessed & reported	n/a
Mansbridge and Brown[44]	359	random	not reported	age	individual	yes	not reported	n/a
Marcenes and Murray[49]	2241	random	good	yes	area	yes	assessed & reported	n/a
Milosevic et al[67]	1035	random	excellent	age	school attended	no	assessed & reported	n/a
Murray	1374	other, well	not	age	individual	yes	assessed but	n/a

et al[45]		described	reported				not reported	
O'Brien [26]	2090	other, well described	excellent	age	individual	yes	assessed & reported	n/a
Pitts[68]	6165	full popln	excellent	age	area	yes	not reported	n/a
Rodd and Chesham[50]	770	other, well described	good	yes	school attended	no	n/a	n/a
Steele et al[46]	4737 (deprivation by school) 1321 (individual deprivation measure)	other, well described	good	age	School attended & individual	yes	assessed & reported	n/a
Tickle et al[69]	7888	random	good	age	area	yes	assessed & reported	n/a
Todd & Dodd[47]	1628	other, well described	excellent	age	individual	yes	assessed & reported	n/a

Table 2.3: Relation of outcome measures to SES (as measured by Registrar General's Classification or NS-SEC)

Outcome	Inverse relationship with SES (reference)	Direct relationship with SES (reference)	No relationship with SES (reference)
Caries (DMFT or DMFS)	(26)r (26) (42)r (44)r (45)r (47)r (46)[a] (46)r[a]		(46)[a] (40) (46)r[a]
Decayed teeth	(26)r (26) (46)[a] (40) (43)r		(46)[a]
D/DMFT	(43)r		
Missing	(40) (46)[a] (26)		(46)[a]
Fillings	(26)r (26)		(40)
Tooth wear/ erosion			(46)
Mean (mm) amelo-cemntal junction to alveolar crest distance			(38)r
CPITN	(41)		
Gum Inflammation			(46) (46)r
Plaque	(42)r		(46) (46)r
Bleeding/ gingivitis	(42)r		(46)
Pocketing			(42)r
Calculus			(46) (46)r
Orthodontic need(as measured by visible irregularity)			(39)
IOTN	(46)[a]		(46)[a]

[a] Whilst an inverse relationship was found for 15 year olds, no relationship was found for 12 year olds

r indicates an actual score of measure has been directly used in the testing whilst those studies without an r have tested the proportion of adolescents considered to have the condition against those considered not to have the condition

Table 2.4: Relation of outcome measures to SES (area based according to postcode or based on school attended)

Outcome	Inverse relationship with SES (reference)	Direct relationship with SES (reference)	No relationship with SES (reference)
Caries (DMFT or DMFS)	(46) (60)r (63)r (48)r (64)r (68)r (68) (46)r		
Decayed teeth	(46)[a] (66)r		(46)[a]
Missing	(46)[a]		(46)[a]
Fillings			(60)r
Extractions			
Tooth wear/ erosion	(58) (67)	(59)	(46)
CPITN			(66)
Gum Inflammation		(46)[b]	(46)[b]
Plaque			(46) (46)r (60)[c]
Bleeding/ gingivitis			(46) (46)r (60)
Pocketing			(60)
Calculus			(46) (46)r (60)
Traumatic dental injuries	(37)		(49)[d] (50)
IOTN	(46)[b]		(46)[b] (61) (62)
IOTN AC			(65)r
IOTN DHC	(69)		(65)r

[a] Whilst an inverse relationship was found for 15 year olds, no relationship was found for 12 year olds

[b] Whilst a direct relationship was found for 12 year olds, no relationship was found for 15 year olds

[c] Was significant for visible plaque only

[d] Based on 1998/99 figures. When looking at overcrowding and ethnic elements of the Jarman index individually, these were significant

r indicates an actual score of measure has been directly used in the testing whilst those studies without an r have tested the proportion of adolescents considered to have the condition against those considered not to have the condition

3 Exploring socio-economic inequalities in self-reported oral health amongst adolescents

3.1 Introduction

Chapter 2 identified that within the UK, those adolescents from lower social classes were more likely to exhibit poorer oral health; they were more likely to exhibit caries and individual components of caries and also have greater unmet orthodontic need. A systematic review clearly demonstrated an inverse relationship between socio-economic status and the prevalence of caries among adolescents (13). This is concerning as most children have all of their permanent teeth (excluding wisdom teeth) by age 13 years and incipient decay is only reversible with rigorous fluoride treatment; otherwise, cavities in secondary dentition are considered non-reversible and must be restored. Oral health problems during adolescence can cause a loss of school days and can lead to problems with self-confidence and social functioning (70, 71). Children who grew up in lower SES families have been found at greater risk of developing periodontal disease and are likely to have increased caries compared to those growing up in higher SES families (72). In order to rectify these inequalities, the underlying causes need to be identified and where possible, changed.

Studies seeking to explain the social gradient in oral health have been conducted previously. A study among 15 year olds in Sri Lanka identified increased use of dental services and tooth brushing had little effect on the observed social gradient in self-reported oral health (73). A study conducted among American adults found that after accounting for potential confounders (age, gender, ethnicity, dental insurance), the following health-related behaviours failed to fully account for socio-economic disparities in oral health: smoking, frequency of eating fresh fruits and vegetables and oral hygiene (74). Further studies among adults have identified dental attendance to attenuate the relationship between SES and oral health (75, 76). However, research identifying the underlying reasons for socio-economic inequalities in oral health among adolescents is lacking.

The purpose of this paper was to determine if known indicators of oral health, as identified in the Fisher-Owens conceptual multilevel model of oral health, (2) explain socio-economic inequalities in self-reported oral health among adolescents.

3.2 Methods

3.2.1 Data source.

The California Health Interview Survey (CHIS) is a population-based random-digit dial telephone survey of California's population. CHIS collects extensive information for all age groups on health status, health conditions, health-related behaviours, health insurance, access to health services and other health-related issues. The data was collected by Westat, a research organization, under the contract with the UCLA Centre for Health Policy Research between July 2007 and March 2008. This study makes use of the 2007 adolescent data set (77).

3.2.2 Sampling strategy.

CHIS employed a multi-stage sample design. First, the state was divided into 44 geographic sampling strata. Second, within each stratum, households were selected through random-digit dial and within each household, one adult (age 18 and over) respondent was randomly selected. In addition, in households where there were adolescents (aged 12-17), one adolescent was randomly selected for interview.

To produce population estimates from the CHIS data, weights were applied to the sample data to compensate for the probability of selection. The weights have been applied to the analyses within this paper as population percentage estimates are reported (table 3.3). A recent study found both the CHIS sample and response rate to be a representative sample of the population of the state (78).

Fisher-Owens model

The Fisher Owens model provides an analytic framework for examining the determinants of oral health in childhood. The model may be tailored to explain different measures of oral health for example, appearance, dental disease, functionality and having pain/ infection. Within this model, oral health is seen as arising from genetic and biological factors, the social environment, the physical environment, health behaviours and dental and medical care (2). The model recognizes the complex interplay of causal factors. Within this analysis, an adapted version of this model was applied to available data on self reported oral health within

CHIS. Although the model is multilevel, data was only available at an individual level, therefore, testing is of a classic rather than a multilevel nature.

3.2.3 Description of variables.

The outcome variable for this study was collected in response to the question, 'How would you describe the condition of your teeth: excellent, very good, good, fair, poor?' This variable was categorized into two groups for the purpose of analysis: excellent/ very good/ good versus fair/ poor. Two commonly used measures of SES, household poverty level (indicated by Federal poverty level) and responding adult's highest educational attainment appear within the CHIS. Household poverty level is categorized into four groups: 300% FPL and above, 200-299% FPL, 100-199% FPL and 0-99% FPL. Responding adult's highest educational attainment is categorized into three groups: Grad school – PhD, some college – BA/ BS degree, grade 12/ high school diploma or lower. Throughout the paper poverty and education are used to indicate household poverty level and responding adult's highest educational attainment respectively.

Potential explanatory variables were chosen to reflect components of the Fisher-Owens model (2). The variables chosen (Table 3.1) have previously shown associations with oral health. Some variables could potentially fall under several headings.

Genetics and biology

As the condition and appearance of teeth is known to vary with age, including during adolescence, age was included in the models (79). Higher rates of caries have been witnessed in females suggesting there is a genetic contribution to oral health (80).

Social environment

Family composition is known to affect oral health as associations have been found between single parent or reconstituted households and increased childhood caries (81). Parent's marital status was therefore included to capture this. As culture is known to impact oral health, citizenship status (adolescent, mother and father), birth country, years lived in the USA and interview language were all included in the models (82). Language spoken at home is indicative of how acculturated immigrants

are into society; hence, language spoken at home has been included within this analysis.

Health influencing behaviours

Etiologically, tooth decay stems from a diet high in sugar (83). Several variables used within this analysis: fast food intake, soda intake and low fruit/ vegetable intake will show signs of this unhealthy diet. BMI has been included as an increase in BMI has been linked with higher DMFT (84, 85) and periodontitis, (86) perhaps because, obesity and caries have common determinants, a diet high in sugar and fat (87). Positive effects of exercise on the body, such as reduced inflammation have been thought to explain the reduced risk for periodontitis among those physically active (88, 89) hence physical activity and sports team membership have been included within the analyses.

Medical and dental care

Use of dental health services, particularly those of a preventive nature, positively impact oral health (90, 91). A number of variables have been included to incorporate frequency and availability of dental health services to the adolescent: time since last dental visit, reason for last dental visit, affordability of dental care and whether or not dentally insured.

3.2.4 Data analyses

Data analyses were performed using STATA 9.0 ©. The variables suspected of influencing teeth condition (table 3.1) were examined individually using logistic regression (data not shown). All variables except age and gender were significant ($p<0.05$) in bivariate analyses (not shown) however, so as to avoid omitted-variable bias, all variables were further examined for inclusion in the multivariate model attempting to explain socio-economic disparities in oral health. The variables were tested for multicollinearity before a multivariate model was developed. Three variables: citizenship status, years lived in the USA and reason for last dental visit, showed signs of collinearity and were subsequently dropped from the multivariate analyses. Five regression models were then constructed using logistic regression as follows (table 3.2). Model 1 contained only poverty and education as the independent

variables and teeth condition as the dependent variable. Next, genetics and biology, social environment, health influencing behaviours and lastly medical and dental care factors were added progressively in models 2-5 respectively. The results of model 5 are shown in table 3.3 below.

3.3 Results

CHIS presented data on 3,638 adolescents, a 44.1% response rate. However, 56 adolescents were excluded due to incomplete/ missing household information resulting in a final sample size of 3,582. Of this, accounting for the weighting, males and females accounted for 51% and 49% of the sample respectively. A majority of adolescents (88%) were born in the United States, 6% in Mexico and 6% in other countries worldwide. Most interviews were carried out in English (91%).

Models

Table 3.2, model 1, confirms socio-economic disparities in self-reported teeth condition; those two groups with the highest poverty and those with the lowest education, had an increased likelihood of reporting poorer teeth condition. This relationship continues in model 2 as age and gender are added. Throughout the remaining models, only those living below the poverty line were more likely to report teeth of a poorer condition however, the odds ratio decreased from 2.96 (2.11, 4.16) in model 1 when no other factors were adjusted for to 1.58 (1.04, 2.41) in model 5 when all factors were adjusted for.

A number of factors showed significance in the final model (table 3.3).Within social environment, being interviewed in Spanish increased the likelihood of reporting poorer teeth condition (OR 2.66 (1.60, 4.41)). Those adolescents who did not speak any English or Spanish at home but instead another language were likely to report teeth of a poorer condition (OR 2.38 (1.04, 5.45)).

A number of health influencing behaviours were associated with teeth condition. Those who were overweight or at risk of being overweight reported poorer teeth condition compared to those of normal weight, with respective odds ratios of 5.60

(4.10, 7.65) and 2.54 (1.83, 3.53). Those undertaking physical activity 2-4 or 5-7 times per week were increasingly less likely to report teeth of a poorer condition than the least physically active, with odds ratios of 0.60 (0.44, 0.82) and 0.55 (0.38, 0.78) respectively. Also, adolescents who were not on a sports team in the previous 12 months were significantly more likely to report poorer teeth condition than those who had been on a sports team (OR 1.99 (1.51, 2.61)).

Among medical and dental care factors, last dental visit remained associated with this measure of oral health in multivariate models. Those who had last visited a dentist more than two years ago or had visited 6 months to one year ago in comparison to those who had visited a dentist within the past six months had increased likelihoods of reporting poorer teeth condition, OR 1.77 (1.03, 3.04) and OR 1.61 (1.18, 2.19) respectively.

3.4 Discussion

This study set out to determine if the relationship between SES and self-reported oral health in adolescents is explained by factors known to influence oral health. This study found that adjustment for genetics and biology, health influencing behaviours, dental care and other aspects of the social environment to partially but not fully account for socio-economic disparities in oral health, which is consistent with previous studies in adults (74, 75). Although this study was conducted on data representing adolescents in California, and some factors explored here such as eligibility for dental insurance vary by state, approximately one in every eight adolescents within the USA lives in California (92).

Health influencing behaviours that remained significant in the final multivariate model included BMI, physical activity and sports team membership. Adolescents who were overweight or at risk of being overweight (in comparison to those of normal weight) reported poorer oral health. The common determinant, a diet high in sugar and fat, would likely explain the observed relationship (87). However, it is possible oral health was reported as poorer amongst those who were overweight or at

risk of being overweight due to lower self esteem as previous studies have highlighted a correlation between these factors (93). Self-reported oral health was better among those who were physically active and those on a sports team. Exercise may prevent periodontitis (88, 89) but this is an uncommon cause of poor oral health in the young and this association may reflect a general healthy lifestyle or better oral hygiene (94).

Dental attendance also remained significant in the final model; those adolescents who last visited a dentist longer than six months ago (other than 1 to 2 years ago) were more likely to report their teeth of a poorer condition than those who had visited within the past six months. Regular dental attendance is important as it affords dentists an opportunity to prevent and treat tooth decay early and must therefore be encouraged, when and where the opportunity arises, amongst adolescents.

It is clear from this dataset that unhealthy lifestyles, which are potentially modifiable, contribute to socioeconomic differentials in oral health. Educating the adolescent population, e.g. via schools or in dental clinics when there is attendance, on the impact of lifestyle choices, such as a healthy diet and regular dental attendance, on oral health may serve to bring about individual behavioural change.

Another way of tackling these unhealthy lifestyle choices is via upstream healthy public policy whereby national policy initiatives are designed to promote population health (95). With respect to improving oral health, heavier taxation of caries-inducing foodstuffs may be an acceptable and effective approach (95). This may decrease the affordability of such health-damaging foods and hence make healthier foods cheaper, relatively speaking.

Disparities in oral health were seen according to interview language and language spoken at home. In particular, adolescents interviewed in Spanish reported poorer oral health. Although low dental utilization rates have been identified among Latinos (96), access to dental services is represented within this study. It would seem non-English speaking adolescents and their parents may not have received adequate information about how to maintain adolescent oral health. This may be amenable to

change by appropriate targeting of information in languages other than English. One approach to delivering this information could be through increasing the number of bi-lingual dental staff while another could be a public health initiative distributing relevant information outside of the dental clinic both orally in schools and through written documentation distributed within appropriate areas. Within California, it would seem the primary language which should be targeted is Spanish but this may change within other states. With increasing immigration into the USA it is important this issue is addressed to prevent widening health disparities and to prevent declines in overall population health.

This study has provided an insight into some of the underlying factors associated with socio-economic disparities in oral health. Addressing such factors may attenuate these disparities. However, after adjusting for all factors, those living in the most poverty were still more likely to self-report poorer oral health. In order to fully explain oral health disparities, further investigations must be carried out.

3.5 Limitations

The CHIS was not primarily established to explore what influences oral health therefore some key data was absent e.g. with respect to fluoridation and oral hygiene. Fluoridation of the water supply is known to have a positive impact on oral health (97) and some of California's population receive fluoridation in their water supply while others do not (98). Despite this limitation, a substantial proportion of the socio-economic differential in oral health was explained by available data. It is possible that these differentials may have been entirely explained had data on fluoridation and oral hygiene been available.

The measure of adolescent oral health within this survey is self-reported teeth condition. Perceived oral health has been found to be associated with a patient's clinically assessed oral health in a number of studies (99-102) and this association has also been seen in adolescents (100). Pitiphat et al. found the validity of self-reported oral health was good for number of remaining teeth, fillings and root canal therapy but less useful for assessing dental caries and periodontal disease (103). This

indicates that self-reported oral health reflects dental work that has been carried out but may not be an accurate reflection of undiagnosed dental disease. This should be borne in mind when interpreting the findings of this study.

Furthermore, the study was cross-sectional and health inequalities may be better investigated using a life course approach which requires longitudinal data (104).

3.6 Conclusion

This study has shown that a number of factors discussed in the Fisher-Owens model of oral health attenuated, but did not fully eliminate, an observed relationship between socio-economic status and oral health in Californian adolescents. Health influencing behaviours, dental care and some social environment factors are modifiable indicating that socio-economic differentials in oral health in adolescents may be amenable to change.

Table 3.1: Suspected determinants of oral health using the model developed by Fisher-Owens

Level	Genetics and biology	Social environment	Health influencing behaviours	Medical and dental care
Child	1.Age 2. Gender	1. Interview language 2. Country of birth 3. Years lived in USA 4. Citizenship status 5. Responding adult's highest educational attainment 6.Language spoken at home 7. Citizenship and immigration status of father 8. Citizenship and immigration status of mother 9. Household poverty level 10. Parent's marital status	1. BMI 2. No. times fast food consumed during past week 3. Fruit/ vegetable consumption 4. No. soda/ sweetened drinks yesterday 5. No. days in week teen physically active for one hour or more 6. Member of sports team in past 12 months	1. Time since last dental visit 2. Couldn't afford dental care in past 12 months 3. Reason for last dental visit 4. Dental insurance

Table 3.2: Relationship between self-reported teeth condition (excellent/ very good,/good versus fair/ poor) and SES with additional covariates: results of univariate/ multivariate analyses (3,582 adolescents in CHIS)

	Poverty	Odds ratio	Education	Odds ratio
Model 1	300% FPL and above	1.00	Grad school – PhD	1.00
	200-299% FPL	1.36 (0.94, 1.98)	Some college – BA/ BS degree	1.04 (0.70, 1.55)
	100-199% FPL	**1.66 (1.18, 2.34)****	Grade 12/ HS diploma or lower	**1.71 (1.11, 2.63)***
	0-99% FPL	**2.96 (2.11, 4.16)*****		
Model 2	300% FPL and above	1.00	Grad school – PhD	1.00
	200-299% FPL	1.36 (0.93, 1.97)	Some college – BA/ BS degree	1.03 (0.69, 1.54)
	100-199% FPL	**1.68 (1.19, 2.38)****	Grade 12/ HS diploma or lower	**1.70 (1.10, 2.61)***
	0-99% FPL	**3.02 (2.15, 4.26)*****		
Model 3	300% FPL and above	1.00	Grad school – PhD	1.00
	200-299% FPL	1.30 (0.89, 1.90)	Some college – BA/ BS degree	1.04 (0.70, 1.56)
	100-199% FPL	1.36 (0.93, 1.98)	Grade 12/ HS diploma or lower	1.51 (0.96, 2.36)
	0-99% FPL	**2.26 (1.52, 3.37)*****		
Model 4	300% FPL and above	1.00	Grad school – PhD	1.00
	200-299% FPL	1.06 (0.71, 1.58)	Some college – BA/ BS degree	0.91 (0.60, 1.38)
	100-199% FPL	1.08 (0.73, 1.59)	Grade 12/ HS diploma or lower	1.15 (0.72, 1.84)
	0-99% FPL	**1.73 (1.14, 2.62)***		
Model 5	300% FPL and above	1.00	Grad school – PhD	1.00

	200-299% FPL	1.01 (0.67, 1.50)	Some college – BA/ BS degree	0.89 (0.59, 1.36)
	100-199% FPL	0.99 (0.66, 1.47)	Grade 12/ HS diploma or lower	1.13 (0.71, 1.82)
	0-99% FPL	**1.58 (1.04, 2.41)***		

* p<0.05, **p<0.01, ***p<0.001

Model 1: Poverty and education only covariates
Model 2: Poverty, education, age and gender as covariates
Model 3: As per model 2 with interview language, birth country, language spoken at home, citizenship status of mother, citizenship status of father and parental marital status as covariates
Model 4: As per model 3 with BMI, fast food consumption, soda consumption, fruit/ vegetable consumption, no. periods physical activity in week and sports team membership as covariates
Model 5: As per model 4 with time since last dental visit, dental insurance and couldn't afford dental insurance as covariates

Table 3.3: Variables influencing self-reported teeth condition (excellent/ very good/ good versus fair/ poor): results of multivariate analyses (3,582 adolescents in CHIS)

Variable	Population (%)	Odds ratio
Teeth condition (dependent variable)		
Excellent/ very good/ good	89.1	n/a
Fair/ poor	10.9	n/a
Independent variables		
Socio-economic variables		
Poverty level		
300% FPL and above	47.9	1.00
200-299% FPL	13.6	1.01 (0.67, 1.50)
100-199% FPL	18.9	0.99 (0.66, 1.47)
0-99% FPL	19.6	**1.58 (1.04, 2.41)***
Responding adult's highest educational attainment		
Grad school – PhD	12.5	1.00
Some college – BA/ BS degree	47.7	0.89 (0.59, 1.36)
Grade 12/ HS diploma or lower	39.8	1.13 (0.71, 1.82)
Genetics and biology		
Age		
12	13.9	1.00
13	16.9	0.93 (0.59, 1.46)
14	18.3	0.91 (0.58, 1.44)
15	15.9	1.09 (0.69, 1.72)
16	17.0	1.11 (0.71, 1.74)
17	18.0	1.13 (0.72, 1.77)
Gender		
Female	49.0	1.00
Male	51.0	0.91 (0.70, 1.18)
Social environment		
Interview language		
English	90.7	1.00
Spanish	8.5	**2.66 (1.60, 4.41)*****
Other	0.8	0.29 (0.06, 1.44)
Birth country		
United States	87.6	1.00
Mexico	6.2	1.00 (0.58, 1.74)
Asia & Pacific Islands	4.0	1.50 (0.68, 3.30)

Other	2.2	0.28 (0.06, 1.22)
Language spoken at home		
English	55.9	1.00
English & Spanish	29.8	1.20 (0.78, 1.84)
English & other	7.4	1.32 (0.71, 2.44)
Spanish	4.0	1.55 (0.78, 3.11)
Other	2.8	**2.38 (1.04, 5.45)***
Father's citizenship status		
US born citizen	56.1	1.00
Naturalized citizen	22.3	0.72 (0.46, 1.13)
Non-citizen	21.6	0.70 (0.43, 1.15)
Mother's citizenship status		
US born citizen	59.5	1.00
Naturalized citizen	17.3	1.21 (0.78, 1.89)
Non-citizen	23.2	1.08 (0.67, 1.76)
Parent's marital status		
Married	62.0	1.00
Never married but live with each other	3.6	0.75 (0.37, 1.54)
Separated/ divorced/ deceased/ other	25.9	0.87 (0.63, 1.20)
Never married, not living with each other	8.5	1.26 (0.80, 2.00)
Health influencing behaviours		
BMI		
Normal	68.4	1.00
Underweight	4.1	0.93 (0.45, 1.90)
At risk overweight	14.4	**2.54 (1.83, 3.53)*****
Overweight	13.1	**5.60 (4.10, 7.65)*****
Fast food consumption in past week		
0 times	23.4	1.00
1 time	31.0	1.17 (0.84, 1.64)
2 times	21.4	0.75 (0.50, 1.13)
3 or more times	24.3	1.18 (0.82, 1.70)
Fruit/ vegetable consumption		
At least 5 a day	20.3	1.00
Less than 5 a day	79.7	1.17 (0.84, 1.64)
Number soda/ sweetened drinks yesterday		
0	42.6	1.00
1	31.8	0.88 (0.64, 1.20)
2-3	22.6	1.35 (0.97, 1.88)
4+	3.1	1.18 (0.82, 1.70)
Physically active		
0-1 times per week	16.6	1.00
2-4 times per week	43.0	**0.60 (0.44, 0.82)****

5-7 times per week	40.4	**0.55 (0.38, 0.78)****
Teen on a sports team in past 12 months		
Yes	51.8	1.00
No	48.2	**1.99 (1.51, 2.61)*****
Medical and dental care		
Last dental visit		
Less than 6 months ago	69.6	1.00
6 months to one year ago	18.5	**1.61 (1.18, 2.19)****
1 to 2 years ago	6.3	1.07 (0.64, 1.79)
More than 2 years ago	4.3	**1.77 (1.03, 3.04)***
Have never visited	1.3	2.31 (0.94, 5.66)
Couldn't afford dental care in past 12 months		
No	94.8	1.00
Yes	5.2	1.31 (0.80, 2.13)
Has dental insurance		
Yes	75.8	1.00
No	24.2	1.01 (0.75, 1.36)

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

4 Literature review: The demand for and provision of dental healthcare

4.1 Introduction

This chapter is a review of the literature which examines adolescent behaviour with respect to use of dental health care amongst adolescents. This literature was identified by carrying out a search of Medline. Search terms were:

1. dental care or dental health services or dental care for children
   And
2. adolescents.

This search identified studies which investigated dental care utilisation amongst adolescents as pertaining to a number of demographics and these are discussed below.

4.2 Empirical studies investigating dental services utilisation

4.2.1 Socioeconomic status

The United Kingdom

Chapter 2 has shown oral health to be closely related to socio-demographic characteristics, for example, those in lower social classes displayed poorer oral health. Despite the fact that oral health care is free to all adolescents in the UK, at the point of use, there exists a body of literature indicating that significant variations exist between socio-demographic groups.

Attwood et al.(52), conducted a cohort study amongst fifteen year olds in the West of Scotland and found significant differences in self-reported regular dental attendance by socioeconomic status (according to occupation of head of household); approximately 82% of males in the highest social class reported regular attendance compared to 40% in the lowest social class while the comparative figures for females were 84% and 71% respectively. When this study controlled for other variables, it found the social class effect to be explained by parental dental visiting behaviours (which were also significantly related with socioeconomic status) and differences in adolescents' smoking habits. Either or both parents regularly attending the dentist

increased the odds of adolescent attendance by three to four times that of neither attending while non-smokers were over three times as likely as smokers to attend regularly.

Hawley and Holloway (7) conducted qualitative research into the factors which could influence dental attendance among 97 adolescents whose parents were considered, 'working class.' An important finding was that, amongst the group, some working class adolescents took responsibility for their own dental care at an early age with some deciding their own dental visiting from as early as twelve years of age. Another finding was that some adolescents did not see themselves at risk from caries; they had misinterpreted previous healthy dental visits to mean it would always be this way. The adolescents mentioned the cosmetic importance of teeth on their social and working lives but failed to mention the importance of teeth from a health aspect. In general, the adolescents showed a low level of interest in dentistry and dental care.

The 2003 National Children's Dental Health Survey (79) showed, amongst 12 year olds, 70% of those from the highest social classes (as measured by occupation of head of household) were regular attenders (those who had visited the dentist in the previous six months for a check-up) compared to 64% of those from the lowest social classes. The survey also identified a difference in dental treatments amongst the social classes; those from the highest social classes were more likely to have experienced a filling but less likely to have experienced an extraction than those from the lowest social classes. This makes sense intuitively, higher social classes have a greater uptake of dental services and as more frequent attenders may be less likely to require radical intervention such as an extraction but more likely to undergo conservative treatment such as fillings. However, this study lacks a longitudinal element in dental attendance which would perhaps serve to better explain treatment patterns witnessed.

Tickle et al. (20) investigated the relationship between SES and dental treatment in the primary dentition of 658 regularly attending children in the North West of England. This retrospective cohort followed the children from 5/6 years of age through until 13-15 years of age. The study found whether a child had ever had an extraction was related to SES (area based measure) while extractions owing to pain

or sepsis were not related to SES. These results suggest dentists are prescribing a greater number of extractions other than those for pain or sepsis to poorer children.

This is not the only study to demonstrate differences in prescribing patterns to children; White and Anderson (105) found 8 year old children who were registered with a dentist and lived in deprived areas had on average 0.38 missing primary molars owing to extraction in comparison to a mean of 0.19 in their peers living in affluent areas. It has been found previously the parents of children from more affluent backgrounds are more likely to demand other types of treatment than extraction whereas parents of children from deprived backgrounds are more likely to expect and accept extraction (106).

USA

The findings from the UK in relation to dental services utilisation and SES are echoed in other countries. Within the United States, the poorest children and adolescents in society can obtain medical and dental care under Medicaid and the State Child Health Insurance Programs. However, studies have shown dental services uptake amongst those eligible for free dental health care is related to socio-economic status (107-109).

Several studies have looked at the uptake of preventive dental services. Preventive dental visits are important as they help to monitor oral health and prevent disease before it occurs and those who avail of these services usually have better oral health status than those who seek oral health care services for emergency care (110).
Yu et al.(111) looked at adolescent uptake of preventive dental services using the model of Aday and Andersen (112). The data analysed came from a sample of 5,644 adolescents aged 11 to 21 years from the National Longitudinal Study of Adolescent Health (collected 1994-1996). While controlling for gender, race/ethnicity, age and health insurance, the study found those whose parents had low levels of education and income were more likely to forgo an annual dental visit. The study also found those adolescents from households with the lowest incomes significantly more likely to have never visited a dentist.

Watson et al. (113) looked at children's and adolescents' use of preventive dental care using the 1996 Medical Expenditure Panel Survey (MEPS) and found poor or near poor children to be significantly less likely than their middle or high income peers to have had such a visit in 1996. This finding stood after controlling for age, sex, race and ethnicity. It is important to note those contained within the poor category were all eligible for Medicaid dental coverage under which children and adolescents have access to Early and Periodic Screening, Diagnostic and Treatment Services which were amended to be more explicit in 1989 (114).

Macek et al. (115) investigated dental attendance amongst 2,642 school children in Maryland and found after controlling for region, race/ ethnicity, parent/ guardian education level and dental insurance status that a measure of socio-economic status, whether the child was eligible for free or reduced meals, was significant in explaining if a dental prophylaxis (preventive) visit had taken place in the past year. This correlation between socio-economic status and having received a dental prophylaxis has been explained as a direct interplay between SES and health-seeking behaviours as reported in other studies (116). That lower SES adolescents were less likely to seek preventive care and hence, also less likely to be regular dental attenders after controlling for dental insurance, is consistent with other studies discussed here.

The New England Children's Amalgam Trial (117) was a 5-year prospective cohort designed to examine trends and reasons for underutilization of free bi-annual preventive dental care provided to children with unmet needs. The significance of such a study is that complexities such as availability of participating dentists, discriminatory treatment and a lack of knowledge of eligibility and benefits on behalf of the patient or primary care-giver are overcome as participants were well informed of their entitlement to this free dental care at the beginning of the study. One part of the study conducted in an urban area found children from households on welfare and those with deep debt were at greater odds of underutilization (low dental attendance in comparison to medium or low/ medium attendance in comparison to high). Financial stress may be associated with long working hours or lack of help with child care and put a strain on time and effort to attend for dental care. This study shows that even when barriers to dental care access related to service charges have been removed, other barriers related to household finances or other circumstances may

remain and deter appropriate utilization. Other studies showed caregivers' attitudes toward dental health create barriers when seeking care, such as transportation difficulties, work schedules, school absence policies and stressful daily events (118-120).

Other countries

Dental care is provided to Spain's childhood population by both public and private health care delivery systems. Children aged between 6 and 15 are entitled to free dental care to include one annual check-up and fillings. A cross sectional study (121) based on secondary individualized data drawn from the Spanish National Health Survey included dental services utilization data on 4,063 children aged 3-15 years. Analysis showed a relationship between SES (as measured by parents' educational level and parents' monthly income) and having a dental visit in the previous twelve months, with the lower social classes significantly less likely to have had such a visit. These results are in line with previous studies conducted in Spain (122, 123). The authors note that the lack of uptake in dental services by the lowest social classes might possibly be explained by the lack of free, publicly funded dental restoration services.

In Chile, the National Health Fund (FONASA) is responsible for providing health care to those 70% of the Chilean population who do not have private insurance (124), this includes the right to free primary dental care. The health care needs of the most affluent 30% of the population are covered by the private insurance system (125). A study (90) conducted in 2000 amongst 9, 203 12-21 year old students found students of lower SES were less likely to have ever visited a dentist, were more likely to be infrequent attenders and were more likely to have last attended for symptomatic reasons. In this study low SES was indicated by a father without income or a mother who had only achieved primary school education. All three relationships were age adjusted. This study strengthens the findings elsewhere that social inequalities play a role in dental attendance amongst adolescents.

4.2.2 Family structure

Several studies have investigated the relationship between dental services uptake and family structure. The National Health Interview Survey, 2002, (126) within the US looked at time since last dental visit for 2-17 year olds by family structure. The survey found those children living with both their mother and father were more likely to have had a dental visit within the past six months (59.9%) in comparison to those living with no mother or father (42.5%). Those living with a father but no mother were most likely to have had a dental visit more than five years ago (21.2%). Similarly, Waldman et al. (127) found children in families with other than two parents present received reduced levels of dental services. Aday and Forthofer (128) identified within the 1986 National Health Interview Survey, that amongst Black & Hispanic 2-17 year olds, members of larger families (three children or more in comparison to one or two children) were less likely to have attended the dentist within the past year.

Whilst Attwood et al. (52) and the 2003 National Children's Dental Health Survey (79) identified the importance of parental dental attendance on adolescent dental attendance within the UK, McGrath et al. (129) investigated how parental attendance may be affected by family structure. They specifically investigated the influence of family size and the impact of children's age on parental dental utilisation. The study found mothers who were married and living with spouse 58% more likely to be regular attenders than those who were not married and living with spouse. The study also found mothers aged 35 or more 48% more likely to be regular attenders than those aged 16-24. The number of children was also a predictor of dental attendance as mothers with more than two children were 40% less likely to be regular attenders compared to mothers with one or two children. Interestingly, household income, employment status and age completed education failed to be significant in explaining regular dental attendance. The study therefore concludes young single mothers with a number of children are at particular risk of failing to monitor their oral health appropriately. With the changing family structure globally, whereby more single parent families exist (130) and the previously discussed correlation between parental and adolescents' dental attendance, this may have consequences on adolescent dental attendance.

4.2.3 Age

A number of studies have investigated the role of age on uptake of dental services in adolescents. The 1998 UK adult dental survey reported 48% of 16-24 year olds were found to go to the dentist less frequently than they did 5 years previously (131). It is suspected this dental avoidance is due to adolescent's ability to influence their own dental attendance (7, 131-134). A study conducted amongst adolescents aged 14-16 years in Liverpool found that more than half of the adolescents felt that they were responsible for taking decisions regarding their dental attendance (132). Adolescents have increased autonomy compared to younger children as there is less parental involvement during this transition from childhood into adulthood.

Hawley at al. (134) recruited 337 13-15-year-olds in Greater Manchester and recorded the frequency and reasons for dental attendance over the previous six years. This age bracket was chosen to capture the time from when they were under their parents' influence into early adolescence when they may have started to take control of their own dental attendance. Subjects were classed as having asymptomatic attendance if they had attended for check-ups at least twice in any three year period. The study found 16% stopped seeking routine dental care in the absence of symptoms during this period. The study also found there was a steady decline in the frequency of all dental visits throughout the study period, from a mean of 2.0 during the 12 months the subjects were 8 years old to a mean of 0.8 visits at the age of 14. The reduction started from the age of 9 years.

4.2.4 Gender

A number of studies have found a difference to exist in the uptake of dental services between males and females in adolescence. (52, 111, 135-138) Attwood et al. (52) found gender to be a significant predictor of regular dental attendance (controlling for social class, parental habits and smoking habits). They found females were over twice as likely to be regular attenders as males. The authors suggest this finding may be explained by females having a tendency, 'to maintain or improve their appearance via a variety of behaviours including attending a dentist.' This may reflect differences in perceived pressures in society on males and females regarding physical appearance.

Yu et al. (111) investigated the use of preventive dental services among a sample of 5,644 adolescents aged 11 to 21 years and found males significantly more likely to have forgone a dental examination in the previous year compared to females, after controlling for other predisposing factors as well as for enabling and need factors. Moon et al. (137) analyzed 4 years of insurance claims data (1991-1995) in the Lower Mississippi Delta region, amongst children aged 5-19 years, to discern patterns of health care utilization, including dental health care. The study found significantly more females used dental services. Similarly, the study conducted in Chile amongst 12-21 year olds (mentioned above) (138) found students who had not attended a dentist within the past year were more likely to be male.

4.3 Conclusions

This chapter has presented empirical research that has examined dental healthcare utilisation amongst adolescents, as measured by dental attendance and service provision and how this varies across a number of demographics. Internationally, SES appears to be a factor in dental attendance. Services provided to adolescents also seem to vary by SES even in cases where attendance rates are similar. Other factors affecting dental attendance in adolescence are family structure, age and gender.

What the studies lack is a comprehensive model that explains the observations made in respect of all variations. The studies do not always examine variations across characteristics with respect to the type of service used and how this changes over time, for example, by socio-demographic grouping, therefore identifying a gap in the literature.

In the next chapter, following a brief overview of two seminal economic papers, a model is presented that integrates the various findings discussed above – education, social class, gender and autonomy, family structure, within a unified model of behaviour, from which, hypotheses are developed and subsequently tested empirically.

5 An economic model of the investment in dental healthcare amongst adolescents

5.1 Introduction

This chapter proposes an investment model to gain insight into access to NHS dental healthcare and intensity of use. First, a brief introduction is given to health economics followed by a discussion on how two seminal economic papers pertinent to healthcare demand (21, 139) are relevant to dental healthcare demand.

Economics is in essence the study of constrained optimisation as it relates to resource allocation by individuals and societies. It can be thought of as the study of how people make choices under conditions of scarcity and what implications these decisions have. Health economics is a sub-discipline of economics and examines constrained optimisation as it arises in health and health care. The optimand is characterized either as health (consistent with the extra-welfarist approach) (140) or social welfare (as characterised in the welfarist approach) (141). Two seminal health economics papers are central to the analysis of decisions regarding health care and may be applied specifically to oral health care, those by Arrow (139) and Grossman (21). Arrow set out the key features that distinguish health care from other tradeable services while Grossman contributed further by using an investment model to characterise decisions regarding health care consumption.

5.2 Arrow

In his seminal article, Arrow (139) sets out a range of factors that combine to distinguish health care from other economic goods and necessitate adjustments to the standard economic models in its analysis. A number of these factors are pertinent to dental health care.

Arrow argues, "A lack of optimality due to the non-marketability of the bearing of suitable risks and the imperfect marketability of information... largely explain the

observed non-competitive behaviour of the medical-care market, behaviour which, in itself, interferes with optimality."

The "bearing of suitable risks," refers to the uncertainty surrounding illness; applying this to oral health, individuals are uncertain as to when they will suffer from toothache or other oral diseases and what the consequences of this, financially or otherwise, might be. As a consequence, some members of society are more willing than others to take chances with their health in the hope that disease will not develop. Within oral health this may mean individuals do not undergo dental check-ups as there is a chance dental disease will not develop.

The "imperfect marketability of information," refers to the deficiencies in the information set which participants exchange in health care markets and the issues that arise from this. Consumers of care often have less information about the need for, effect of, or what might be a reasonable charge for their care. This asymmetry places the provider at an advantage that affords the opportunity for the patient to be exploited, through for example demand inducement. This is known as the principal agent problem where, when applied within dentistry, the dentist acts as an agent on behalf of the patient, diagnosing disease, recommending and then providing treatment. Demand inducement can occur if for example a patient is administered a scale and polish more frequently than clinical need would dictate. Strict ethical guidelines exist within health care provision to ensure in so far as possible, health care providers act in the best interest of the patient and that all treatment decisions are divorced from self-interest[1]. This may be especially important where (aspects of dental reimbursement) provision is reimbursed on a fee for item service; the more care that is provided the higher is the income generated.

The principal agent relationship may be extended beyond that involving the dentist and the adolescent to include parents/ guardians. Parents/ guardians are likely to act as an agent influencing their children's' dental attendance and registration. This influence is likely to be stronger amongst younger adolescents and weaken over time

[1] Within the UK, the General Dental Council is responsible for the protection of dental patients by setting appropriate standards of practice and conduct for dental professionals.

as the adolescent develops increased autonomy. No studies were identified which examined the principal agent relationship in adolescence.

Arrow also discusses that another distinguishing feature of the health care market is that entry to the market is often conditional on licensure from the appropriate professional and governmental body (e.g. state recognised medical school). While this may provide a mechanism by which the quality of service can be assured, it also has the effect of restricting supply. This can increase the monopoly power of the supplier limiting the extent to which competition will reduce supply inducement. (142, 143) The monopoly creates a situation whereby the utility of health care providers is maximised as opposed to the utility of the patient.

5.3 Grossman

In 1972 Grossman developed the Human Capital Model of the Demand for Health (21). The extent to which this model can be used to explain choices individuals make with regard to dental healthcare may be limited due to differences which exist between health care demand and dental healthcare demand. Grossman used data from the 1963 health interview survey in Chicago[2]. Important, lifestyle and dietary changes have occurred across the last five decades and these must be considered.

Within his model, Grossman describes health capital as one component of human capital; a person inherits an initial stock which depreciates with age and at an increasing rate after some stage in life. Grossman argued that health is demanded for two different reasons; purely as an investment commodity providing an individual with healthy time for market and non-market activities and secondly as a consumption commodity whereby sick days are a source of disutility and healthy days a source of utility. Health is demanded by individuals as a source of utility but it is also produced by them through for example consumption of healthcare. Dental healthcare and in addition to self-care are used in the production of oral health.

[2] The survey was conducted by the National Opinion Research Center and the Center for Health Administration Studies of the University of Chicago. Grossman estimated demand curves for health and medical care and gross investment production functions.

The model predicts that as a person ages the rate at which health depreciates increases. With age, the cost both in terms of own time and healthcare required to maintain a given level of health increase, these forces explaining the observation that increasing age (after a certain level) is associated with a simultaneous reduction in health and increasing medical expenditures. With respect to oral health for example, a reduction in oral health with age could be explained by an increase in time over which teeth are exposed to bacteria that cause tooth decay. In response to treating decay, dental healthcare use would be expected to increase with age (in keeping with Grossman).

Grossman's model went beyond this simple approach where demand is related to need to incorporate income and education as further elements of a more fully specified model. Using his model, Grossman found the wage rate was positively associated with the demand for health. Intuitively this makes sense as applying the human capital approach those with higher incomes will have a greater potential loss of earnings from sick days (as income increases so the return on investment rises and the opportunity cost of a sick day rises) and may generally derive greater utility from healthy days.

However, Grossman found healthy time had negative income elasticity. This was attributed to a greater consumption of negative health influencing products such as rich food, cigarettes and alcohol by those with higher incomes. Within the medical care demand function, Grossman found the wage rate had a non-significant negative coefficient where, due to the negative income elasticity of healthy time he expected a positive coefficient. Applying the human capital approach to oral health and dental care in the present time period would be expected to show marked differences. Although it may have been the case in the 1960's that negative health influencing products were more affordable to the higher earners in society, in the present time, lower earners are expected to be higher consumers of sugar which is one of the major causes of poor oral health amongst adolescents. That those of lower SES were found to have poorer oral health as found in the systematic review in chapter 2 would support this. Also, the nature of dental care must be considered; preventive dentistry is an important part of maintaining oral health so therefore those demanding oral

health are likely to demand this type of dentistry and perhaps consume more dental care overall.

Grossman found education had a significant coefficient in the health demand function. An extensive review of the literature conducted by Grossman and Kaestner (144) suggests that years of formal schooling completed is the most important correlate of good health. Assuming a causal relationship from schooling to health, more educated persons may be more efficient producers of health. Grossman (145) discusses that, 'Productive efficiency pertains to a situation in which the more educated obtain a larger health output from given amounts of endogenous (choice) inputs.' Several explanations are offered for this; the more educated may be more knowledgeable about what contributes to good health and what hinders it and the more educated may be quicker to respond to new information which becomes available concerning good health. Alternatively, it may be that the more educated are better able to navigate the health care system. Within the context of an investment model, for the better educated, if the ability to produce health is greater and costs are lower, return on investment, everything else being equal, will be higher. This finding has implications for dental healthcare, as, those who are more educated are more likely to demand health and therefore may be greater users of preventive dentistry and perhaps orthodontic treatment which can increase the aesthetic appearance of teeth.

Alternative explanations for a relationship between schooling and good health that remain consistent with the Grossman investment model have however, also been offered. Fuchs (146) argues persons who have a low rate of time preference are likely to discount future benefits from any investment less heavily. When comparing these with current costs, the decision to invest is more likely to be positive and thus those who attend school for longer periods are also likely to be those observed making larger investments in health. That is, the link between health and education is affected through time preference. In a telephone survey he conducted, Fuchs measured time preference by asking respondents to choose between a sum of money now and a larger sum in the future. In this study, Fuchs was not able to demonstrate time preference explains the relationship between schooling and good health. However, these results must be regarded as preliminary as they are based on a small sample of adults in Long Island and use an exploratory measure of time preference.

This research could help to explain the intergenerational relationships between parents and children. Parents can raise their children's future health by making them more future orientated. It is therefore important for parents to invest in their children's schooling and hence lower their time preference for the present and raise their future health.

Upon looking at the demand function for medical care, Grossman found the schooling coefficient is positive but not significant. A negative relationship between schooling and the demand for medical care would have been expected due to the finding of a positive correlation between schooling and good health. However, schooling is likely to be positively correlated with health insurance coverage leading to an upward bias in its estimated effect. Again, when applying this to dental care, a positive relationship would be expected between preventive dentistry whereas negative relationships may be witnessed for some treatments such as extractions and endodontics. These ideas will be further developed in the proposed economic model.

5.4 Model

A model to gain insight into access to NHS dental healthcare and intensity of use is now proposed. The following is an investment model in which parents act as the agents on behalf of the child. The parents' role diminishes over time as the adolescent matures and has increased autonomy hence making their own decisions. Dentists in turn act as agents informing parents when care is required and the nature of this care. This may further complicate the model, for reasons that will become apparent. For simplicity, it is assumed dentists act as perfect agents providing only such care as the patient would themselves demand were they fully informed.

The investment decision can be written in the form of a standard net present value (NPV) equation:

$$NPV\ (I_t) = \frac{a_1}{(1+r)} + \frac{a_2}{(1+r)^2} + \frac{a_3}{(1+r)^3} + \ldots + \frac{a_n}{(1+r)^n} \qquad (1)$$

Where NPV is the net present value of the individual investing in dental healthcare and represents a stream of all future expected benefits of health expressed in monetary terms

a_n denotes the difference in the value of health benefits and costs in any given time period (of which there are n)

r denotes the discount rate which is used to express net value in its present value and represents the time preference of the individual

n denotes the number of years of life remaining

Underpinning the model is the assumption that individuals are utility maximizers and seek to maximise the net benefit to them from any given decision. Investment in dental healthcare will entail more than consumption of dental health services but implicit in the consumption of such services is a decision to invest in oral health. Such investment requires registration with an NHS dentist as no use of public services is possible in the absence of registration. Investment however, implies not just access but actual use and moreover requires knowledge of the type of use – the nature of the investment made or type of care consumed. Both decisions are examined here. This allows for a richer analysis than previous studies which have investigated use of dental health care using attendance or an incomplete picture of treatments provided.

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This model accords a role to a number of variables such as costs, expected future benefits and discount rates; variables that are likely to vary with respect to a range of demographics and socio-demographics. This model incorporates a role for specific aspects of SES; HRP NS-SEC (a proxy for income) and HRP highest educational attainment, both of which will be discussed further within the model.

5.4.1 Discount rate

For adolescents, while care is publicly funded and monetary costs likely to be trivial, there may be inconvenience in attending a visit as well as costs associated with pain and discomfort from dental treatment. While costs are incurred wholly or ostensibly in the present, benefits in terms of better oral health will be enjoyed in the current and in future time periods. When making decisions regarding current care, the

individual discounts future benefits to compare them with current costs thus according a role for discount rates in the decision to register and consume care. If benefits are heavily discounted, NPV is more likely to be negative than would otherwise be the case and consumption of care not observed.

Discount rates are likely to be higher for adolescents than for parents, that is, children are likely to discount the future more heavily through a higher rate of time preference. Children may be more likely to focus on their well-being it the present and hence may derive greater utility from leisurely activities in comparison to dental visiting. They may be somewhat ignorant to the risks they are undertaking with regards their oral health in not making regular dental visits. Parents however, have greater life experience and would be more aware of the oral health risks presented by failing to regularly attend a dentist. As a result of lower time preference amongst parents, the model predicts greater investments when parental influence over adolescents' decisions is greater; this is likely to be amongst younger adolescents. This gives rise to the first hypothesis that can be examined empirically:

Hypothesis one

H0: There exists no difference in dental registration between younger and older adolescents

H1: There exists a difference in dental registration between younger and older adolescents[3]

Note that with the alternative hypothesis, tests for a difference in the duration of registration between younger and older adolescents but does not specify the direction of this relationship. To specify the direction of the relationship would be wrong as it could in fact be either way. Expectation of a difference in a particular direction is not adequate to justify creating a hypothesis which cites one variable will be greater than the other and subsequently carrying out one tailed statistical testing (147). This will be the same case throughout all hypotheses stated in this chapter.

[3] Although the economic model predicts the direction of this relationship, two tailed testing of this hypothesis will be conducted as the possibility that the reverse relationship exists cannot be ruled out at this stage.

Time preference is also likely to vary with education (one measure of SES); better educated HRP are likely to have a lower discount rate as a result of a lower rate of time preference. Therefore, they are more likely to invest now in order to receive higher future benefits as they derive higher utility from future net benefits. Further, those who are more educated may be more likely to consume particular types of care e.g. preventive care[4] than those with higher rates of time preference. They may also be more likely to consume orthodontic treatment which in the short-term may look unsightly but has long-term aesthetic benefits. In order to obtain the benefits of preventive and orthodontic treatment, those with low discount rates may be more likely to remain registered with a dentist, whilst those with a higher time preference are more likely to exhibit a sporadic registration and attendance pattern due to for example symptomatic dental visits driven by immediate needs related to pain.
In relation to this, the following hypotheses will be tested:

Hypothesis two
H0: There exists no difference in registration according to HRP education
H1: There exists a difference in registration according to HRP education[5]

Hypothesis three
H0: There exists no difference in orthodontic treatment provision according to HRP education
H1: There exists a difference in orthodontic treatment provision according to HRP education[6]

In Northern Ireland, community background (Catholic and Protestant) have often been used as surrogate markers for socio-economic background[7] (148). As it is

[4] Although preventive dental treatments such as topical fluoride and fissure sealants are generally not provided by NHS dentists, regular dental attendance affords the dentist an opportunity to tackle dental disease by removing plaque and is also an opportunity for the dentist to offer preventive advice

[5] Although the economic model predicts the direction of this relationship, two tailed testing of this hypothesis will be conducted as the possibility that the reverse relationship exists cannot be ruled out at this stage

[6] Although the economic model predicts the direction of this relationship, two tailed testing of this hypothesis will be conducted as the possibility that the reverse relationship exists cannot be ruled out at this stage

[7] O'Reilly and Stevenson identified the greater the percentage of Catholics in an area, the greater the level of disadvantage; this relationship was observed in respect of the following variables:

possible that SES measures available do not necessarily capture all aspects of SES, it may be expected that community background will continue to feature as a determinant of investment decisions. For example, Catholics have been previously identified as having poorer lifestyle habits such as smoking and drinking[8] (149). Such habits could be reflected in a higher discount rate with associated lower investment levels, ceteris paribus, a different pattern of investment; relatively higher levels of restorative care to orthodontic care. It is conceivable that if such risky behaviour results in shorter life expectancy, this results in a shorter time period over which benefits of investing in dental health can be enjoyed. (150) Catholics may therefore have less time over which to accrue benefits from any investment[9] and this may be reflected in a different pattern of decisions, for example, lower registration rates. In relation to this, the following hypothesis will be tested:

Hypothesis four

H0: There is no difference in dental registration according to community background

H1: There exists a difference in dental registration according to community background[10]

5.4.2 Benefits

Consider now, the role of parental income proxied in this case by occupation of head of household according to NS-SEC (another measure of SES). Health plays an important role in generating utility, while in turn, utility is generated from health and from other goods. For those on higher incomes, health may be valued more highly because the marginal product of health in the income production function will be

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unemployment, long-term unemployment, children in non-earner households, educational attainment and income support.

[8] This study found Protestants were half as likely as Catholics to have smoked at some time in their lives; this association remained after controlling for educational qualifications. Protestant men were half as likely to be heavy drinkers as catholic men.

[9] Data from this study showed, amongst both males and females, Catholics had significantly lower life expectancy than all Protestant religions (Presbyterian, Church of Ireland, Methodist and other Christian). The greatest differences were between Catholic (76.13 (75.60, 76.77)) and other Christian (79.30 (78.04, 80.55)) males.

[10] Although the economic model predicts the direction of this relationship, two tailed testing of this hypothesis will be conducted as the possibility that the reverse relationship exists cannot be ruled out at this stage

higher; if every unit of health produced one unit of healthy time, for those on higher incomes healthy time would be valued more highly. Moreover, the benefits of dental care may differ depending on the type of care involved and differences may be apparent here across NS-SEC. For example, among higher NS-SEC aesthetic appearance may be more important for employment and income than for lower NS-SEC. It follows that orthodontic treatment may be valued more highly because of its' contribution to future income and perhaps also due to greater social acceptance among higher NS-SEC.

Although higher income may mean a higher opportunity cost of visiting the dentist in terms of working time lost, this model assumes this not to be the case and that short-term working loss is compensated for during normal working hours. Arising from this are the following hypotheses:

Hypothesis five

H0: There is no difference in dental registration according to HRP NS-SEC

H1: There exists a difference in dental registration according to HRP NS-SEC[11]

Hypothesis six

H0: There is no difference in orthodontic treatment provision according to HRP NS-SEC

H1: There exists a difference in orthodontic treatment provision according to HRP NS-SEC[12]

Differences may similarly emerge with respect to gender. Females may perceive that society places more pressure on them than on males to look attractive. Females are therefore likely to derive higher utility from oral health generally and in particular from that which can be observed (for example through orthodontic use). Therefore, we may be more likely to observe dental registration and orthodontic treatment in females than males. In accordance with this the following hypotheses will be tested.

[11] Although the economic model predicts dental registration will be higher amongst those with a HRP of higher NS-SEC, within statistical testing of this hypothesis, two tailed testing will be conducted as the possibility that the reverse relationship exists cannot be ruled out at this stage.

[12] Although the economic model predicts the direction of this relationship, two tailed testing of this hypothesis will be conducted as the possibility that the reverse relationship exists cannot be ruled out at this stage

Hypothesis seven

H0: There is no difference in dental registration according to gender

H1: There exists a difference in dental registration according to gender[13]

Hypothesis eight

H0: There is no difference in orthodontic treatment provision according to gender

H1: There exists a difference in orthodontic treatment provision according to gender[14]

5.4.3 Costs

Costs of travelling to the dentist are likely to vary with distance required to travel however, Northern Ireland is a small country so this may not be the case. In relation to this, the following hypothesis will be tested:

Hypothesis nine

H0: Dental registration does not vary according to distance to closest dentist

H1: Dental registration does vary according to distance to closest dentist[15]

Family characteristics such as structure, relating to parents' marital status and family size are likely to restrict resources such as money and time, impacting on dental registration. As mentioned above, utility is derived from health and other goods and services. When time and money are limited, there is more likely to be a trade-off between these goods. Within single parent families, one parent is likely to be responsible for day to day running of the household including all aspects of parenting. This increased responsibility is likely to restrict time and require better

[13] Although the economic model predicts the direction of this relationship, two tailed testing of this hypothesis will be conducted as the possibility that the reverse relationship exists cannot be ruled out at this stage

[14] Although the economic model predicts the direction of this relationship, two tailed testing of this hypothesis will be conducted as the possibility that the reverse relationship exists cannot be ruled out at this stage

[15] Although the economic model predicts the direction of this relationship, two tailed testing of this hypothesis will be conducted as the possibility that the reverse relationship exists cannot be ruled out at this stage

organisational skills to maintain dental registration. Co-habiting families may also display reduced dental registration if co-habitation is positively correlated with greater instability in family structure. Evidence exists to suggest that many co-habiting unions for example are likely to be short-lived[16] and adolescents may face living within a lone parent family or with the parent's new partner who is not a biological parent. Arising from this is the following hypothesis:

Hypothesis ten

H0: Dental registration does not vary according to family structure

H1: Dental registration does vary according to family structure[17]

Similar issues relating to time and organisational skills may exist for families with large numbers of children especially if children attend different schools. Money required to travel to and from dental appointments may be more restricted within both single parent families and families with more children, hence dental registration may be associated with these factors. In association with this, the following hypothesis will be tested:

Hypothesis eleven

H0: Dental registration does not vary according to family size

H1: Dental registration does vary according to family size[18]

This chapter has proposed a model of the investment in dental healthcare amongst adolescents. Chapter 6 will describe the methods undertaken to empirically test this model.

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[16] Bumpass and Lu (2000) found over 50% of cohabiting unions in the US, whether or not eventually legalized by marriage, ended by separation within five years compared to roughly 20% for marriages.

[17] Although the economic model predicts the direction of this relationship, two tailed testing of this hypothesis will be conducted as the possibility that the reverse relationship exists cannot be ruled out at this stage

[18] Although the economic model predicts the direction of this relationship, two tailed testing of this hypothesis will be conducted as the possibility that the reverse relationship exists cannot be ruled out at this stage

6 Methodology

6.1 Data

This study made use of a unique dataset which was formed by linking requested variables from two datasets: the NILS (provided by NISRA) and dental registration and treatment reimbursement data (provided by BSO). On all official documentation, this study was referred to as project 033, 'An exploratory analysis of adolescent dental health and use of dental care services in Northern Ireland.' All data transfers were subject to the Data Protection Act (1998) and the Human Rights Act (1998). The data transfer agreement between BSO and NISRA stated this data would remain available for three years through 2009/10, 2010/11 and 2011/12. After this, the data may be archived by NISRA for one year beyond 2011/12 and destroyed thereafter.

6.1.1 NILS data

The NILS is a large-scale data linkage study which is created by linking administrative and statistical data. Information on people is linked over time from Census data, birth and death registrations and demographic data derived from health card registrations. NILS members are selected from health card registrations based on 104 annual birth dates. The sample is designed to capture approximately 28% of the Northern Ireland population. Actual variables requested from NISRA are listed in Appendix 3. It was important to ensure all variables relevant for the analyses were requested, as once the linkage described below had taken place, the dataset was final. Therefore, this explains why some variables requested at this stage were not used within the final analyses.

Study group

The study group was those born between 1st April, 1990 and 31st March, 1992. This therefore means subjects were had their 12th or 13th birthday during 2003/04 and their 16th or 17th birthday during 2007/08.

SES variables

The variables chosen to represent SES within this study were NS-SEC (2001)[19] of HRP (see abbreviations for explanation of HRP) and highest level of qualification of HRP which were both taken from the 2001 Census. Categories for both NS-SEC of HRP and highest level of qualification of HRP can be viewed in Appendix 5. Since 2001 NS-SEC has been used to describe occupation and replaced Social Class based on Occupation (SC) and Socio-economic Groups (SEG). NS-SEC aims to differentiate positions within labour markets and is therefore representative of source and amount of income.

The second variable chosen to represent SES was highest level of qualification of HRP. This study categorised highest level of education of HRP on four separate levels: degree and above, two or more a-levels, GCSEs and no qualifications. Those HRP not aged 16-74 were uncategorised with regards highest level of education. Although there exists no formal way to define education, these four categories represent the four main tiers of educational attainment within the UK.

Other variables

Other variables from the NILS used within this study were family type, number of siblings and community background. Family type was represented on three levels by married, co-habiting and lone parent. Those who did not fall into one of these three categories (such as multi-couple households) were classified 'anomaly' family type. Community background referred to the community background of the adolescent and was represented by Catholic, Protestant or other community background. Number of siblings was derived from variable RELP 1-6 which indicated the adolescent's relationship to each person within the household.

Age and gender were taken from Core NILS data and based on health card registration.

Status history is another variable included within the NILS and is taken from the six monthly downloads based on health card registration. If an individual has a health

[19] A full description of NS-SEC can be viewed at the Office for National Statistics website http://www.ons.gov.uk/about-statistics/classifications/current/ns-sec/index.html

card registration in Northern Ireland this will show in their six monthly download. This variable therefore gauges the continuity of the NILS member within Northern Ireland and this was useful for this study as it allowed identification of those who were living in Northern Ireland throughout the study period.

6.1.2 BSO data

The data requested from BSO (Appendix 4) related to all dental registrations and dental treatments carried out by the NHS high street dentists across the financial years 2001/02 – 2007/08. Although within Northern Ireland NHS dentistry is also provided by the community dental service and the hospital dental service, this information is not readily available. The implications of this are discussed alongside the discussion sections. Additional variables relating to distance to closest dentist at April 2008 and distance to dentist most recently used were also requested. Although this study conducts analyses with regard to specific treatments, the information on all treatments was required so as to get overall expenditure per adolescent.

Examination of the registration data revealed incompleteness for the years 2001/02 and 2002/03 as registration was only available for 12 of the 24 months. This was due to the nature of the way dental registration data was collected in the past. It was then decided to drop these two financial years from all subsequent analyses as in doing so, a more complete picture could be provided. Analyses within this study were therefore conducted across five financial years 2003/04 – 2007/08.

6.1.3 Data approval process

Research Approvals Group (RAG)

First it was necessary to submit an initial NILS application form to the RAG. This application (see appendix 7) consisted of:

- Funding details
- Background and aims of the study
- Publication and dissemination of findings
- Description of data required

The RAG granted approval for this project on 16th April, 2009.

The Office for Research Ethics Committees Northern Ireland (ORECNI)

Although NISRA had already obtained ethical approval for the creation of the NILS on 3rd October, 2007, it was necessary to submit a 'notice of substantial amendment,' to ORECNI to allow the merging of NILS and BSO data. This project obtained clearance from ORECNI on 17th December, 2008.

Data Transfer Agreement

In order to clarify with NILS and BSO specific data to be linked, it was necessary to draw up a data transfer agreement. This agreement included details on all data to be provided as well as file specifications.

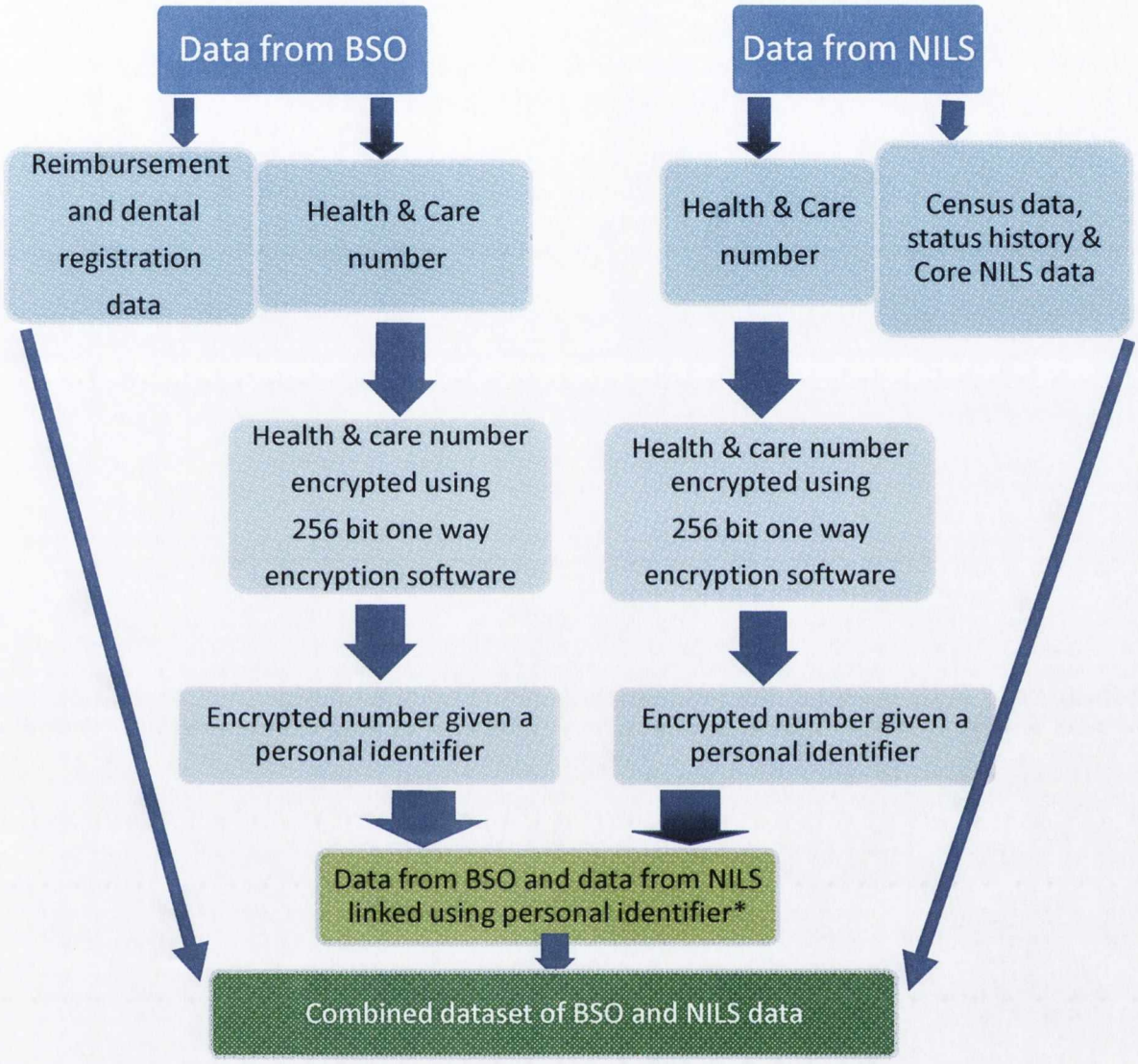
6.1.4 Data Linkage

In order to preserve anonymity, this linkage was done via a one-way encryption on health & care number available in both datasets (demonstrated in figure 6.1). Within both datasets, individuals were then represented by a unique identifier. The NILS and the BSO datasets were then merged using this unique identifier and health & care number was not provided. Researchers on this project were provided with this final dataset only, and therefore health & care number was not made available to them at any stage hence preserving total anonymity. The linkage was carried out by NISRA during September 2009 using 256 bit one-way encryption software.

The NILS sample for this period was 15, 276, therefore, linking the NILS and BSO data files gave information on 15, 276 adolescents. Adolescents contained within the BSO files but not in the NILS were dropped at this stage[20].

[20] It is not possible to do any comparative analyses on this data as once BSO and NILS data were matched, unmatched data were destroyed in accordance with NILS policies.

Figure 6.1: Data linkage of BSO and NILS data



* At this stage, those adolescents who appeared in the BSO file with a birth date between April 1st, 1990 and March 31st, 1992 but who were not in the NILS were removed and therefore not included in any analyses.

6.1.5 Formatting the data files

BSO data

Due to the 'raw' nature of the dental files, a considerable amount of work had to be carried out to get the information into a format that could be analyzed more easily. The dental files provided by BSO were 'treatment based.' This meant if an individual had been administered six different treatments across the five years, they were allocated six rows in the treatment file, one for each separate treatment. Work was

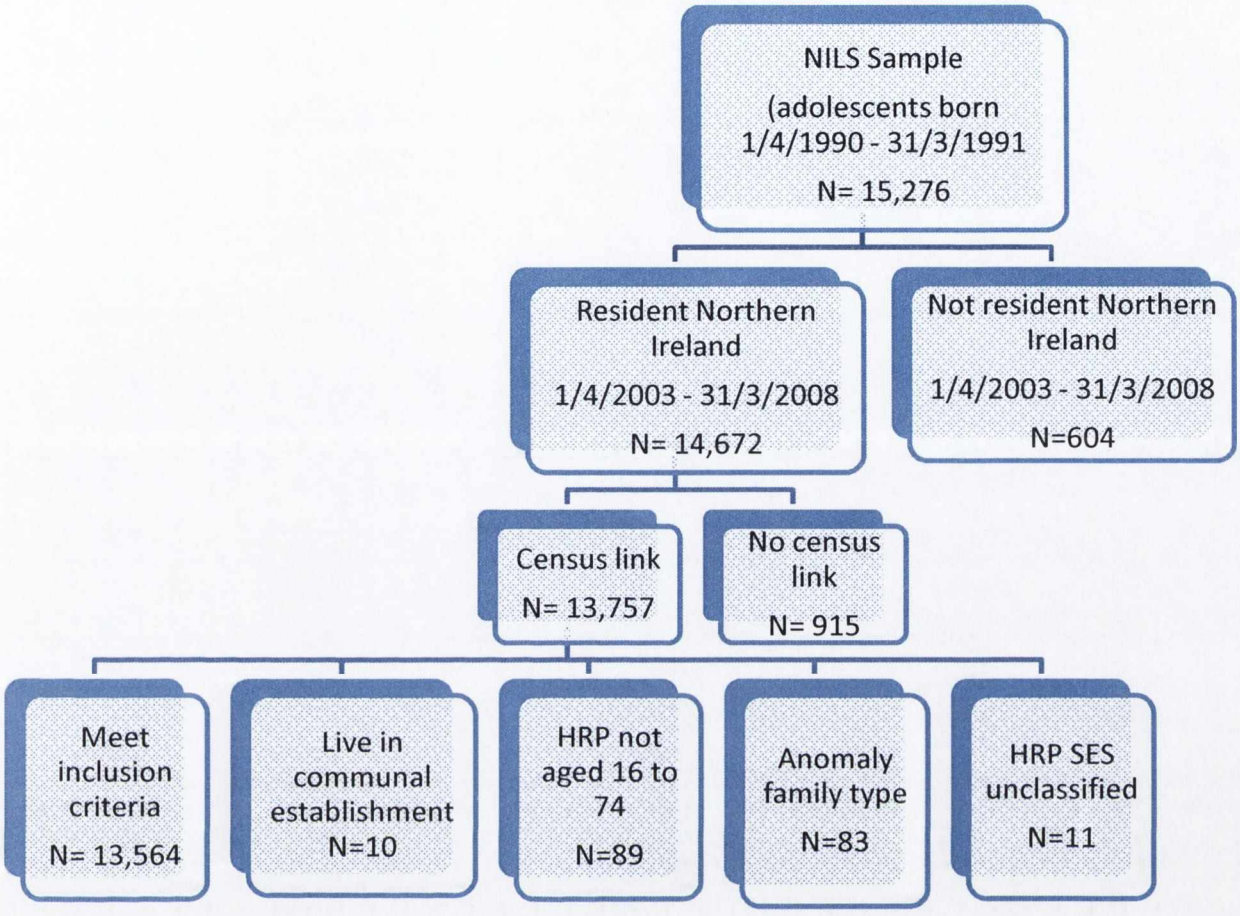
carried out on these files to make them 'person based,' and to therefore have one row allocated to each individual showing all treatments carried out and the years in which they took place. The treatments were categorized under the following areas:

1. Conservative treatment in three separate areas
    - Fillings
    - Endodontic treatment
    - Other conservative (porcelain veneers, inlays and crowns, bridges)
2. Orthodontics
3. Extractions
4. Other treatment (preventive care, periodontal treatment, prostheses and other (non-orthodontic) appliances)

Due to the nature of the NILS, information on members may not be complete across entire time periods as people migrate in and out of the country. As this study was a retrospective cohort, it was necessary to only include those who resided in Northern Ireland across the entire time period from April, 2003 to March, 2008. A variable within the NILS captures, bi-annually, whether or not a sample member was resident or not. From the total 15, 276 adolescents, 14, 672 were resident within Northern Ireland throughout the entire study period and were therefore included. It was then necessary to delete a further 915 adolescents as no Census information had been provided for them. A further 10 adolescents were dropped as they lived in communal establishments such as care homes and did not have vital individual level data such as SES and highest educational qualification of HRP required for this study, leaving 13, 747 in the study.

A further 183 adolescents were excluded due to the HRP not being between the ages of 16 and 74 (89), an anomaly family type (83) or SES of HRP equal to other (11). This left 13,564 adolescents in the final sample to be analysed. Figure 6.2 shows the inclusion/ exclusion procedure.

Figure 6.2: Exclusion/ inclusion of adolescents



6.1.6 Data analyses

In order to adhere with NILS regulations, all data analyses were carried out within a secure location at NISRA headquarters, McAuley House between the hours of 9am and 6pm. STATA was provided by NISRA for statistical analyses.

Results of data analyses were required to go through a screening process by NILS staff before they could leave the secure location. NILS' regulations did not permit results reporting on categories which contained less than ten people, therefore, any results which reported on or identified such categories were deleted and not allowed to leave the secure location. NILS regulations also meant NISRA staff had to screen all conference abstracts, research papers and this thesis. This was to ensure proper description and acknowledgement of NILS, and to further enforce no disclosure of categories containing less than ten people.

6.2 Statistical methods

All statistical methods employed within this thesis are now discussed. Within individual chapters, specific methods used are referenced.

6.2.1 The multiple linear regression model

The multiple linear regression model is used to study the relationship between a dependent variable and one or more independent variables. The generic form of the linear regression model is:

$$y = f(x_1, x_2, \ldots, x_k) + \varepsilon$$
$$= x_1\beta_1 + x_2\beta_2 + \ldots + x_k\beta_k + \varepsilon$$

Where y is the dependent variable and x1, ... , xk are the independent variables. ε is a random disturbance which arises due to the difficulty of capturing every influence on an economic variable in a model. The random disturbance may also capture errors in measurement. Within this dataset errors in measurement may apply to monthly dental registration records held by BSO or expenditure on dental treatments.
The generalised linear model seeks to estimate the unknown parameters of the model. The validity of theoretical propositions may then be studied. Within this study, as many of the independent variables are categorical, dummy variables will be created in which each dummy is compared to the reference category. Appendix 5 lists the variables and reference categories.

Assumptions of the regression model

1. Linearity. $y_i = x_{i1}\beta_1 + x_{i2}\beta_2 + \ldots + x_{ik}\beta_k + \varepsilon_i$, specifies a linear relationship between $x_1, \ldots, x_k$.
2. Full rank. There is no exact linear relationship among any of the independent variables in the model.
3. Exogeneity of the independent variables. $E(\varepsilon i / x_{i1}, x_{i2}, \ldots, x_{ik}) = 0$. This states that the expected value of the disturbance at observation i in the sample is not

a function of the independent variables observed at any observation, including this one. Therefore, the independent variables will not be able to predict ε_i.

4. Homoscedasticity and nonautocorrelation. Each disturbance ε_i has the same finite variance, σ^2 and is uncorrelated with every other disturbance εj.
5. Exogenously generated data. The data in (x_{j1}, x_{j2}, ..., x_{jk}) may be any mixture of constants and random variables. The process generating the data operates outside the assumptions of the model – that is, independently of the process that generates ε_i.
6. Normal distribution. The disturbances are normally distributed.

A least squares approach is then used to find the parameters β_1, $\beta_{2,...,}$ β_k.

Testing for heteroscedasticity

Heteroscedasticity means disturbance terms ε_i do not have the same finite variance σ^2 and this is problematic when using least squares estimation. One way of testing for heteroscedasticity is White's test (151). Within this test, the following hypothesis is tested:

H_o: $\sigma_i^2 = \sigma^2$ for all i

H_1: σ_i^2 does not equal σ^2 for all i

The following steps are taken in White's test:

1. Obtain the residuals of the estimated regression equation
2. Use the squared residuals as the dependent variable and estimate the following equation where X's are explanatory variables from the original equation

$$(ei)^2 = \alpha_0 + \alpha_1 x_{i1} + \alpha_2 x_{i2} + \alpha_3 x_{i3} + \alpha_4 x^2_{i1} + \alpha_5 x^2_{i2} + \alpha_6 x^2_{i3} + \alpha_7 x_{i1} x_{i2} + \alpha_8 x_{i1} x_{i3} + \alpha_9 x_{i2} x_{i3} + u_i$$

3. Test the joint hypothesis that all the coefficients are zero. The test is asymptotically distributed as chi-squared with P-1 degrees of freedom, where P is the number of regressors in the equation, including the constant.

In the presence of heteroscedasticity, robust standard errors are reported. A heteroskedasticity-robust t statistic is then obtained by dividing an OLS estimator by its robust standard error. Heteroscedasticity can cause the standard errors of the coefficients to be underestimated and therefore incorrectly judge a relationship to be statistically significant when it is not.

6.2.2 The logistic regression model

Logistic regression is used when the dependent variable is dichotomous. An extension of logistic regression is multinomial logistic regression, used when the dependent variable has more than two outcomes and when these outcomes can be ordered, it is appropriate to use ordered logistic regression.

The logistic regression equation is:

$$z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k$$

where,

z is the log odds of the dependent variable = ln(odds(event))

β_0 is the constant

$\beta_1, \ldots, \beta_k$ are the logistic regression coefficients applying to the independent variables, $X_1, \ldots, X_k$

Logistic regression uses maximum likelihood estimation after transforming the dependent into a logit variable (the natural log of the odds of the dependent occurring or not). The logistic regression then calculates changes in the log odds of the dependent variable.

In the case of ordered logistic regression, the log odds of being in a higher category is calculated. For example, if outcomes are ordered 1-3 then the log odds will consist of being in category 2 or 3 compared to 1 or being in category 3 compared to 1 or 2. If the independent variables consist of more than two categories, dummy variables are created and comparison each time is to a reference category. Appendix 5 outlines independent variables and their reference categories are in bold.

Unlike OLS, logistic regression does not assume linearity in the relationship between the independent and dependent variables and does not assume homoscedasticity. It does require observations be independent and that the independent variables be linearly related to the logit of the dependent variable.

Models for count data

6.2.3 The Poisson regression model

Variables which represent counts of the number of occasions an event has occurred in a population (for example within this thesis, a count variable which arises is number of months registered with a dentist) often arise in statistical analysis. In principle, these data could be analyzed using multiple linear regression but the preponderance of zeros and small values and clearly discrete nature of the dependent variable suggest least squares may be improved on with a specification that accounts for these zeros. Such a model used is the Poisson model (152). Under this assumption, the events must occur independently, in which case, the occurance of an event should not influence the probability of an event occurring in another individual in the population. In a Poisson distribution, the variance of the counts will be equal to the mean.

The Poisson regression model specifies that each y_i is drawn from a Poisson distribution with parameter λ_i, which is related to the regressor $\mathbf{x}_i$. The primary equation of the model is:

$$\text{Prob}\,(Y_i = y_i / \mathbf{x}_i) = \frac{e^{-\lambda i}\,\lambda_i^{yi}}{y_i!} \qquad y_i = 0,1,2,\ldots$$

The most common formulation for λ_i is the loglinear model,

$$\text{Ln}\,\lambda_i = \mathbf{x'}_i\,\boldsymbol{\beta}$$

The expected number of events per period is given by

$$E\,[y_i / x_i] = \text{Var}\,[y_i / \mathbf{x}_i] = \lambda_i = e^{x'i\beta}$$

So

$$\frac{\partial E[y_i / \mathbf{x}_i]}{\delta \mathbf{x}_i} = \lambda_i \boldsymbol{\beta}$$

In principle, the Poisson model is a nonlinear regression. However, it is far easier to estimate the parameters with maximum likelihood techniques. The log-likelihood function is

$$\ln L = \sum_{i=1}^{n} (-\lambda_i + y_i \mathbf{x}'_i \boldsymbol{\beta} - \ln y_i !)$$

The likelihood equations are

$$\frac{\partial \ln L}{\partial \boldsymbol{\beta}} = \sum_{i=1}^{n} (y_i - \lambda_i) \boldsymbol{x_i} = \mathbf{0}$$

6.2.4 The negative binomial regression model

Another way of modelling count data is to use the negative binomial regression model which does not rely on the assumption of equality of the conditional mean and variance. The Poisson model is generalized by introducing an individual, unobserved effect into the conditional mean.

$$\text{Ln } \mu_i = \mathbf{x'}_i \boldsymbol{\beta} + \varepsilon_i = \ln \lambda_i + \ln \mu_i$$

Where the disturbance ε_i reflects either specification error as in the classical regression model or the kind of cross-sectional heterogeneity that normally characterizes microeconomic data. Then, the distribution of yi conditioned on xi and as in the classical regression model or the kind of cross-sectional heterogeneity that normally characterizes microeconomic data. Then, the distribution of yi conditioned on $\mathbf{x}_i$ and μ_i (i.e. ε_i) remains Poisson with conditional mean and variance μ_i:

$$f(y_i / \mathbf{x}_i, \mu_i) = \frac{e^{-\lambda i, \mu i} (\lambda_i \mu_i)^{yi}}{} \qquad y_i = 0,1,2,\ldots\ y_i!$$

The unconditional distribution $f(y_i / \mathbf{x}_i)$ is the expected value (over μ_i) of $f(y_i / \mathbf{x}_i, \mu_i)$.

A more detailed discussion of the negative binomial regression model is contained in a textbook by Greene (153).

6.2.5 The likelihood ratio test

The likelihood ratio (lr) test is used to determine if omitting an independent variable from a model significantly reduces the fit of the model. The lr test requires that two models be run, one of which contains all the independent variables and a second which drops one or more independent variables. The lr test compares the log likelihoods of the two models and tests whether this difference is statistically significant. The model with more variables will nearly always fit better, however, if the difference is statistically significant, this model is said to fit the data significantly better.

The lr test is calculated in the following way:

$$lr = 2\,(LL\,(m2) - LL\,(m1))$$

Where

LL(m2) is the natural log of the likelihood of model containing all independent variables

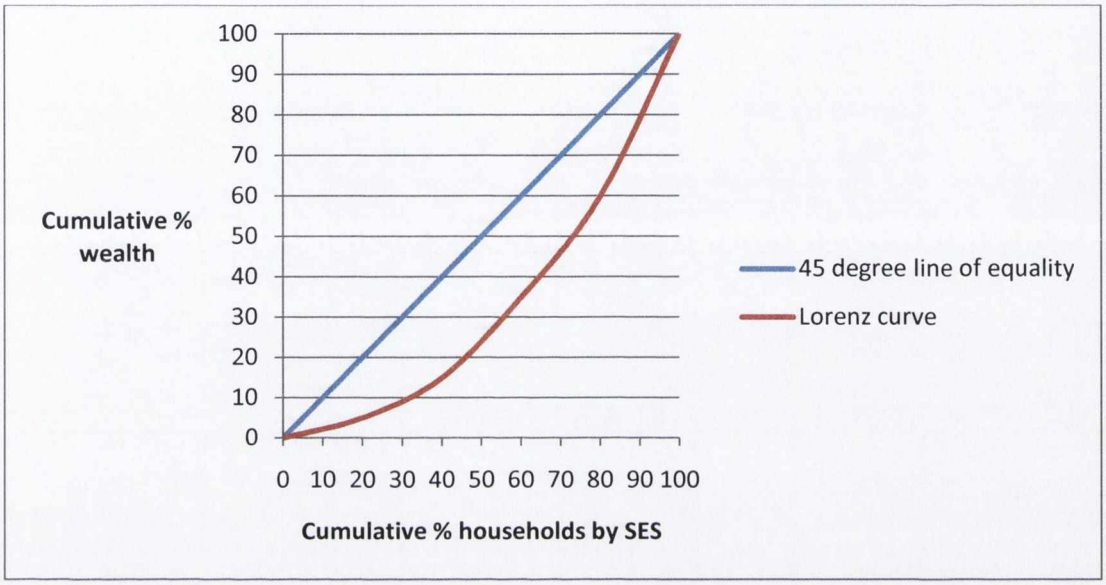
LL(m1) is the natural log of the likelihood of the model with omitted independent variables

6.2.6 Concentration curves

The concentration index and related concentration curve provide a means of quantifying the degree of inequality (measured by some deprivation measure) in a particular variable, in this case dental healthcare expenditure. The concentration index and concentration curve are based on the Gini coefficient and Lorenz curve respectively. The Lorenz curve measures the degree of income-related inequality in society by ranking household income from smallest to largest and graphing cumulative percentage of households along the x-axis with cumulative percentage of income along the y-axis. A Lorenz curve is shown in figure 6.3 below. The Gini coefficient is equal to twice the distance between the line of equality and the Lorenz curve, therefore ranging from zero to one; zero represents perfect equality (everyone

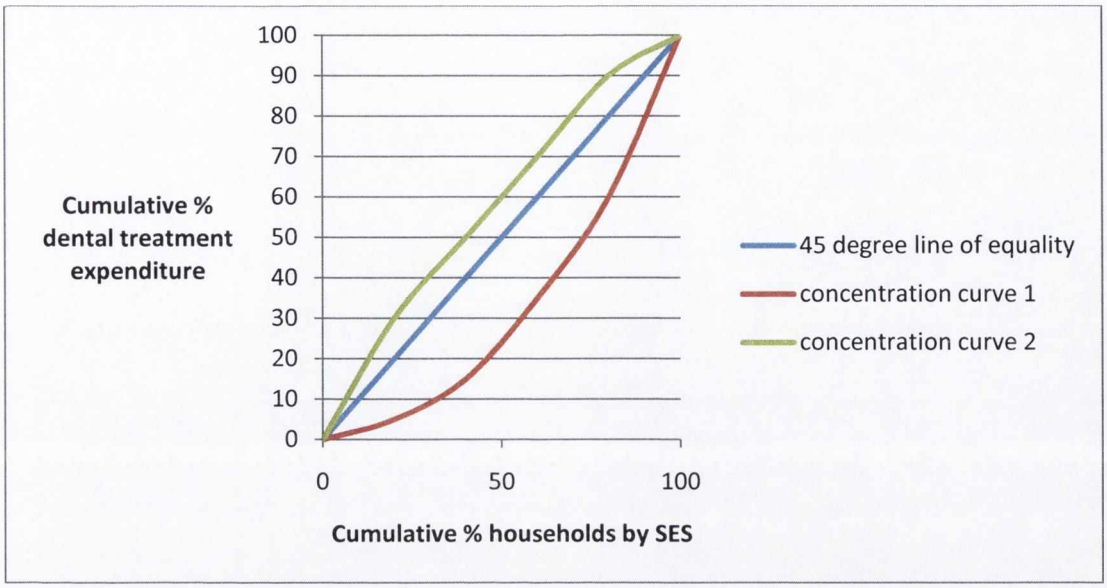
in society has exactly the same income) and one represents total inequality (one person in society has all the income while all other members of society have no income).

Figure 6.3: Example Lorenz curve



The concentration curve and concentration index are based upon the Lorenz curve and Gini coefficient except inequalities under examination vary from wealth. Within this thesis, inequalities by SES in dental expenditure within the NHS are examined. This means that the curve can now fall above or below the line of inequality as demonstrated in figure 6.4. The concentration index is calculated in the same way as the Gini coefficient and equals the area under the line of equality minus the area under the concentration curve, multiplied by two. This therefore means the concentration index may be positive (as represented by concentration curve 1) or negative (as represented by concentration curve 2). Concentration curve 1 indicates dental treatment is more concentrated in those households of higher SES whereas concentration curve 2 indicates dental treatment is more concentrated in those households of lower SES.

Figure 6.4: Concentration curves



In order to calculate concentration indices, data are initially sorted by increasing SES of HRP, ranging from never worked/ long-term unemployed to professional. The concentration index is then calculated using the following formula:

$$C = (p_1L_2 - p_2L_1) + (p_2L_3 - p_3L_2) + \ldots + (p_{T-1}L_T - p_TL_{T-1}),$$

Where p is the cumulative percent of the sample ranked by economic status, L_p is the corresponding concentration curve ordinate, and T is the number of socioeconomic groups.

In order to test for significance, a standard error can be computed for C using the following formulae. Let n denote the sample size, T the number of groups, f_t the proportion of the sample in the *t*th group, μ_t the mean value of health variable amongst the *t*th group, and C the concentration index.

$$\text{var}(C) = \frac{1}{n}\left[\sum_{t=1}^{T}(f_t a_t{}^2 - (1+C)^2)\right] + \frac{1}{n\mu^2}\sum_{t=1}^{T}(f_t \sigma_t{}^2 (2R_t - 1 - C)^2)$$

let R_t be the fractional of the t'th group, defined as

$$R_t = \sum_{y=1}^{t-1}(f_y) + \frac{1}{2}f_t$$

Where, ${\sigma_t}^2$ is the variance of μ_t,

$$a_t = \frac{\mu_t}{\mu}\,(2R_t - 1 - C) + 2 - q_{t-1} - q_t$$

$$q_t = \frac{1}{\mu}\sum_{y=1}^{t}\mu_y f_y$$

Which is the ordinate of L(p), $q_0 = 0$ and

$$p_t = \sum_{y=1}^{t} f_y R_y$$

A spreadsheet can be found on the worldbank website which will calculate concentration indices and associated standard errors[1].

[1]http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTHEALTHNUTRITIONANDPOPULATION/EXTPAH/0,,contentMDK:20216933~menuPK:400482~pagePK:148956~piPK:216618~theSitePK:400476,00.html

7 Exploring the relationship between dental registration and demographics amongst adolescents

7.1 Introduction

This chapter aims to test the economic model on demand for dental health care amongst adolescents developed in chapter 5. In doing so, the relationship between dental registration across the years 2003/ 2004 – 2007/ 2008 and a number of socio-demographics/ demographics thought to influence dental registration are investigated; SES, family structure, family size, community background, gender and adolescent age. Dental registration is investigated in three ways:

1. Total duration of registration
   - Mean number of months registered
   - Those who were registered for the maximum possible time
   - Those who were not registered at all

2. Breaks in registration

3. Changes in registration across the period 2003/04 – 2007/08

7.2 Methods

7.2.1 Dental registration in the NHS

Within the NHS, children who are under 18 years old or who are 19 years old and in full time education may register with an NHS dentist for dental check-ups and treatment. The dentist then receives a monthly capitation fee and receives additional payment for other items of service such as fillings, extractions and orthodontic treatment if provided, on an item of service basis. Under current rules, dental registration lapses for an individual if they have not attended the dentist for 15 months. Dental registration may therefore be taken as a signal of regular dental attendance as well as an indication of desire to retain access to publicly funded dental services. Current guidelines from NICE recommend children under 18 years should attend for a check-up every 3-12 months, depending on how the dentist assesses their individual needs (154). Dentists do not have to inform patients when they are being deregistered and they are not obliged to re-register patients. As a consequence, patients may have difficulty registering with an NHS dentist if they are deregistered or if they have never been registered.

The dataset described in 6.1 was used for analyses undertaken here.

7.2.2 Variables

This study makes use of four outcome variables; number of months registered, full registration (binary variable), no registration (binary variable) and total number of breaks in registration. The outcome variables represent different aspects of dental registration and will be discussed below.

Registration was available on a monthly basis across the years 2003/04 – 2007/08 for all months excluding April 2003, 2005 and 2007 and February, April, December,

2006[21]. Therefore, number of months registered was a discrete variable ranging from 0-54 months. Within binary variables full registration and no registration, those registered for all 54 months and those registered for 0 months respectively were allocated 1 whilst all others were allocated 0. A break in registration was defined as each unique movement from a registered to a non-registered status.

Covariates

Two variables commonly used to represent SES are included within these analyses; NS-SEC and highest educational attainment of the household reference person. As discussed within the economic model (5.4), these variables have been used within these analyses to represent specific aspects of SES. HRP NS-SEC acts as a proxy for inter alia income. In discussion, it will be its' role as a proxy for income that will be focused on though it is conceded it may reflect other aspects of social class such as flexibility with working patterns (often important as dental appointments can be scheduled during regular working hours). HRP highest educational attainment reflects inter alia time preference such as the ability of the individual to navigate the healthcare system. In the discussion though, it will be its' role as a proxy for time preference that will be focused upon.

Independent variables, gender, family type, family size and community background have also been included.

7.2.3 Hypotheses

As detailed in the model, a number of hypotheses emerged with respect to demand for dental care. This chapter examines a number of hypotheses with specific regard to dental registration. Hypothesis one is:

H0: There exists no difference in dental registration between younger and older adolescents

H1: There exists a difference in dental registration between younger and older adolescents

[21] These six months were removed from all analyses as errors in numbers registered were identified in the data provided by BSO. Errors were identified after the one way data linkage had taken place and were therefore not able to be rectified.

This emerged with respect to the change in the rate of time preference between adults and adolescents, where the latter was postulated to be higher and would become more dominant in decision making as the child aged. In order to investigate this hypothesis, average months registered in 2003/04, when adolescents were 11-13 years old, was compared to average months registered in 2007/08 when adolescents were 15-17 years old. The maximum number of possible months registered was 11 for both 2003/04 and 2007/08.

Hypotheses two, four, five, seven, nine, ten and eleven examine differences in dental registration according to HRP education, community background, HRP NS-SEC, gender, distance to closest dentist, family structure and family size respectively. For each of these hypotheses, average cumulative number of months registered across 2003/04 to 2007/08 was examined. The number of months registered with a dentist is indicative of the amount of time the adolescent had access to dental healthcare. In addition to this, breaks in registration amongst those registered were examined. Although there is likely to be a high correlation between average months registered and breaks in registration, breaks in registration will indicate the possible sporadic pattern of dental attendance (due to the fifteen month deregistration rule already mentioned in 1.2.1 above). Sporadic attendance may indicate a pattern of registration driven by specific needs (e.g. toothache) in comparison to an attendance pattern with few or no breaks in registration.

In addition to average number of months registered and breaks in registration, binary variables representing full registration and no registration were examined in relation to the seven variables in the hypotheses discussed above. It is important to know the characteristics of those who had access to GDS across the entire five year period and of those who had no access.

7.2.4 Statistical methods

In examining total duration of registration (Table 7.1) (including separate analyses for 2003/04 and 2007/08 (Table 7.3)) and number of breaks in registration (Table 7.1), linear regression (OLS) was used with dummy variables created within each

covariate, to allow comparison to the reference category. Appendix 5 shows each of the covariate categories with associated reference categories.

As duration of registration and number of breaks in registration, are count data, it was also feasible to use count regression models such as poisson and negative binomial models which do not require the data to be normally distributed. However, as the number of observations increases, the dependent variable becomes approximately normally distributed under the central limit theorem (155). Therefore, it is not important to use count regression models with large datasets. Negative binomial and poisson models were also run for duration of registration and breaks and no material differences to the overall significance (results not shown) were detected. OLS models were tested for heteroscedasticity and standard errors adjusted to robust standard errors in the presence of heteroscedasticity.

In examining full registration and no registration (binary variables), logistic regression was used. The same covariates and reference categories used to examine duration of registration and breaks in registration (Appendix 5) were used. A description of all statistical tests used in these analyses are presented in section 6.2.

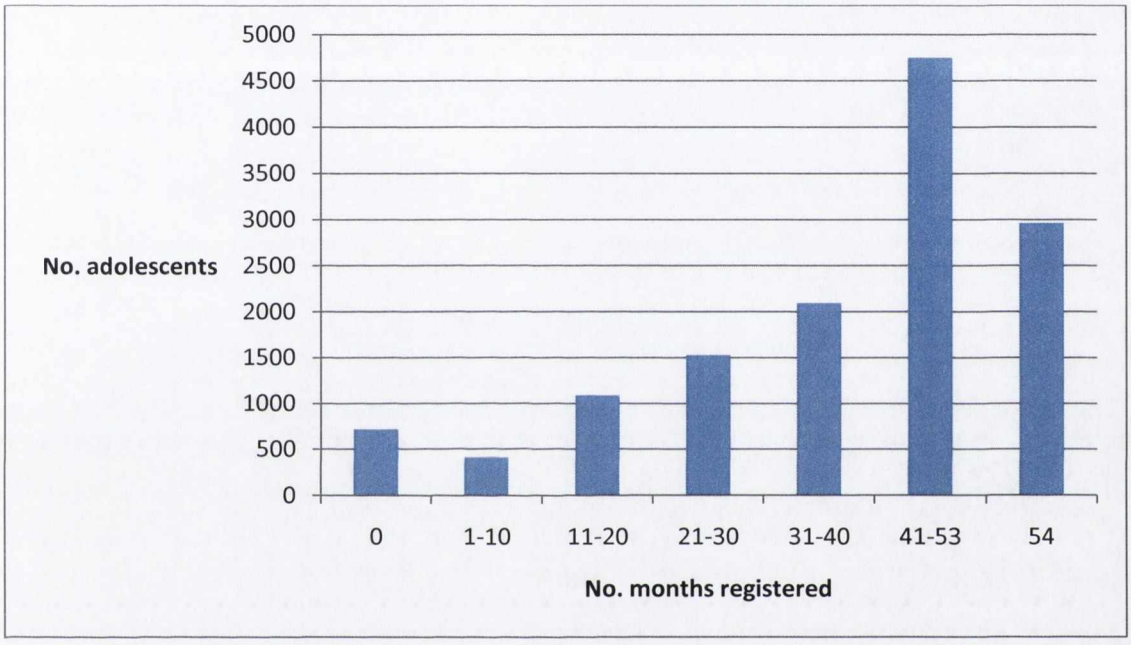
7.3 Results

This study represented data on 13,564 adolescents (as discussed in 6.1.5). The characteristics of this sample are shown in Appendix 5. Within this sample, males accounted for almost 52% of the population while almost half of the sample was Catholic. A majority of the adolescents lived within married families (74.1%) and lone parent families (22.5%) while the remaining small percentage lived in co-habiting families. NS-SEC of HRP revealed a majority were professionals or semi-routine, 29.2 % and 23.9% respectively. Almost 40% of adolescents had a HRP with no qualifications while a further 37% had GCSEs. Around two thirds of adolescents had one or two siblings. Two thirds of adolescents lived within two km of an NHS dentist.

7.3.1 Dental registration

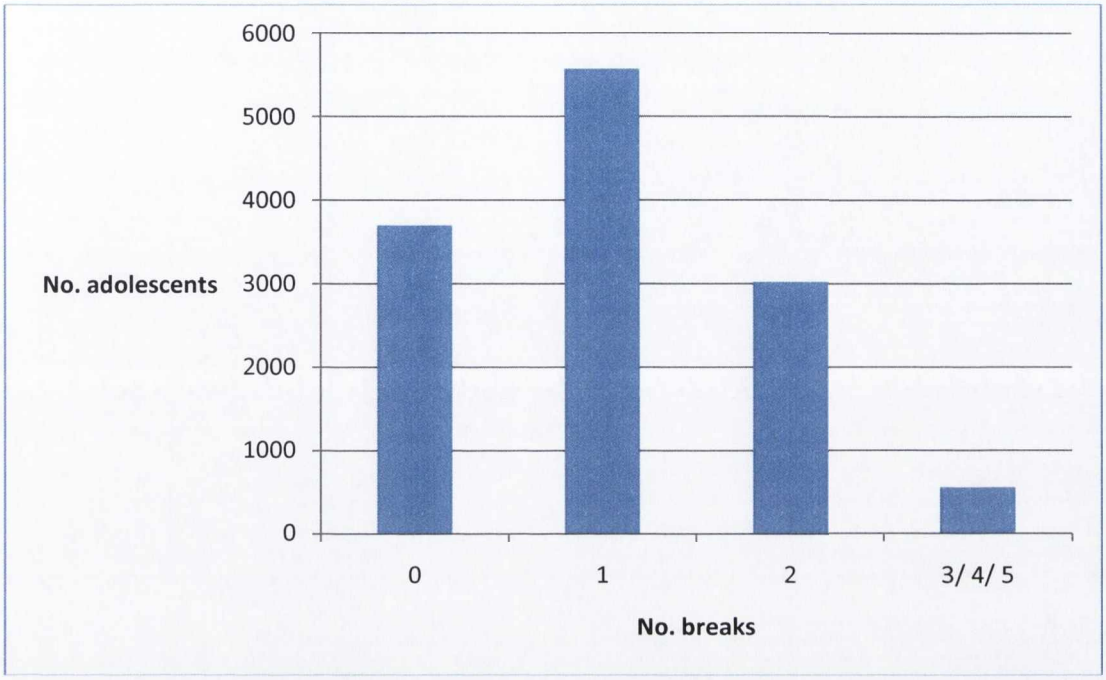
Figure 7.1 shows the distribution of months registered across the years 2003/ 2004 – 2007/ 2008. A majority of adolescents (4,749) were registered for 41-53 months, while a further 2,963 adolescents were registered for the maximum period. From the sample, 718 adolescents were not registered with an NHS dentist at any time.

Figure 7.1: No. months registered 2003/04 - 2007/08 (13,564 adolescents in NILS)



Breaks in registration were examined amongst the 12,846 adolescents who were registered for at least one month during the 2003/04 – 2007/08 period. Including those who had no period of registration would have artificially deflated these figures, as it was not possible for them to break their registration. The number of breaks in registration ranged from zero to five. 3,700 adolescents had zero breaks, 5,570 had one break, 3,020 had two breaks while the remaining 556 had 3-5 breaks as shown in figure 7.2 below.

Figure 7.2: No. breaks in registration 2003/04 - 2007/08 (12,846 adolescents in NILS)



Multivariate models

Results are shown in table 7.1

Dental registration and SES

Table 7.1 shows disparities according to HRP NS-SEC within multivariate analyses. Distance to closest dentist was not significant and so therefore, results have not been reported on. Compared to adolescents whose HRP was a professional (registered for 43.08 months on average), those from semi-routine, routine and never worked/ long-term unemployed backgrounds were registered for significantly less months on average, 40.28, 39.20 and 37.20 respectively. Amongst those with some period of registration, those adolescents with a semi-routine, routine, or never worked/ long-term unemployed HRP had on average more breaks in registration, 0.97, 1.00 and 1.02 respectively, compared to adolescents with a professional HRP who had on average 0.91 breaks. This evidence supports H1 in hypothesis five, dental registration varies according to HRP NS-SEC.

Those adolescents with lower educated HRP's were found to display lower average lengths of registration; degree and above were registered for 43.08 months compared to GCSEs who were registered for 40.75 months and no qualifications who were registered for 37.73 months on average. Similar results were identified in relation to average number of breaks; those adolescents whose HRP had GCSEs or no qualifications had significantly more breaks, 1.02 and 1.06 respectively, compared to those whose HRP had a degree or above, who had 0.91 breaks on average. This supports H1 in hypothesis two, dental registration varies according to HRP education.

Dental registration and other factors

Females displayed on average significantly higher levels of registration than males; 44.48 months compared to 43.08 months. In addition to this, females had on average fewer breaks in registration compared to males, 0.88 breaks compared to 0.91 breaks. This supports H1 in hypothesis seven, there exists a difference in dental registration according to gender.

Inequalities relating to family type were observed with those from co-habiting and lone parent families showing lower average registration, 37.87 months and 38.26 months respectively compared to those from married families who were registered on average for 43.08 months. Those adolescents from lone parent families had on average more breaks in registration compared to those from married families, 1.05 compared to 0.91. This supports H1 in hypothesis ten, dental registration varies according to family structure.

Inequalities relating to family size were observed; compared to those with no siblings, those with four siblings had significantly lower mean registration, 43.08 months compared to 40.11 months respectively. Adolescents with three siblings had on average more breaks in registration than those with no siblings, 0.98 compared to 0.91. This supports H1 in hypothesis eleven, registration varies according to family size.

Analyses of dental registration according to community background revealed Protestants displayed significantly higher mean registration than Catholics, 44.88

months compared to 43.08 months. Protestants also had on average fewer breaks in registration, 0.78 compared to 0.91. These findings support H1 in hypothesis four, dental registration varies according to community background.

In order to investigate if distance to dentist was a factor in dental registration, distance from home to nearest dentist was included in a further multivariate model in which distance was not significant (results not reported). This supports H0 in hypothesis nine, dental registration does not vary according to distance to closest dentist.

7.3.2 No registration

Table 7.2 shows the results of multivariate logistic regression exploring those who were not registered at all throughout the 2003/04-2007/08 period.

No registration and SES

Analyses of those not registered for dental services at all throughout the 2003/04 – 2007/08 period revealed disparities by HRP NS-SEC. Adolescents whose HRP NS-SEC was routine or never worked/ long-term unemployed were 47% and 50% respectively, more likely to not have registered at all, compared to professionals.

Analysis by HRP education revealed that adolescents from households in which the HRP had no qualifications were almost twice as likely as those where the HRP had degree and above to not have registered throughout the entire period.

No registration and other factors

Females had a decreased odds ratio of 0.79 of not being registered at all throughout 2003/04 – 2007/08 period compared to males. Disparities witnessed in relation to family type revealed those adolescents living within co-habiting families or lone parent families twice as likely and 33% more likely respectively, to not have registered throughout 2003/04 – 2007/08 than those from lone parent families. Those adolescents with one sibling had a decreased odds ratio of 0.69 of not being registered at all throughout the five year period than those adolescents who were an only child.

7.3.3 Full registration

Table 7.2 shows the results of multivariate logistic regression exploring those who were registered for the maximum possible 54 months across the 2003/04-2007/08 period.

Full registration and SES

Analyses revealed those adolescents from households where the HRP NS-SEC was semi-routine, routine or never worked/ long-term unemployed had decreased odds of 0.80, 0.70 and 0.49 respectively of being registered for the maximum possible time in comparison to those where the HRP was a professional.

Disparities were identified according to HRP highest educational attainment; those adolescents from households where the HRP had GCSEs or no qualifications had decreased odds of 0.69 and 0.56 respectively of being registered for all 54 months compared to degree and above.

Full registration and other factors

Females were 13% more likely than males to have had full registration. Disparities witnessed in relation to family type showed adolescents from co-habiting and lone parent families had decreased odds ratio of 0.67 and 0.54 respectively of having full registration compared to adolescents from married families. Those adolescents from community backgrounds Protestant and other were 56% and 38% respectively, more likely to have had full registration than Catholics.

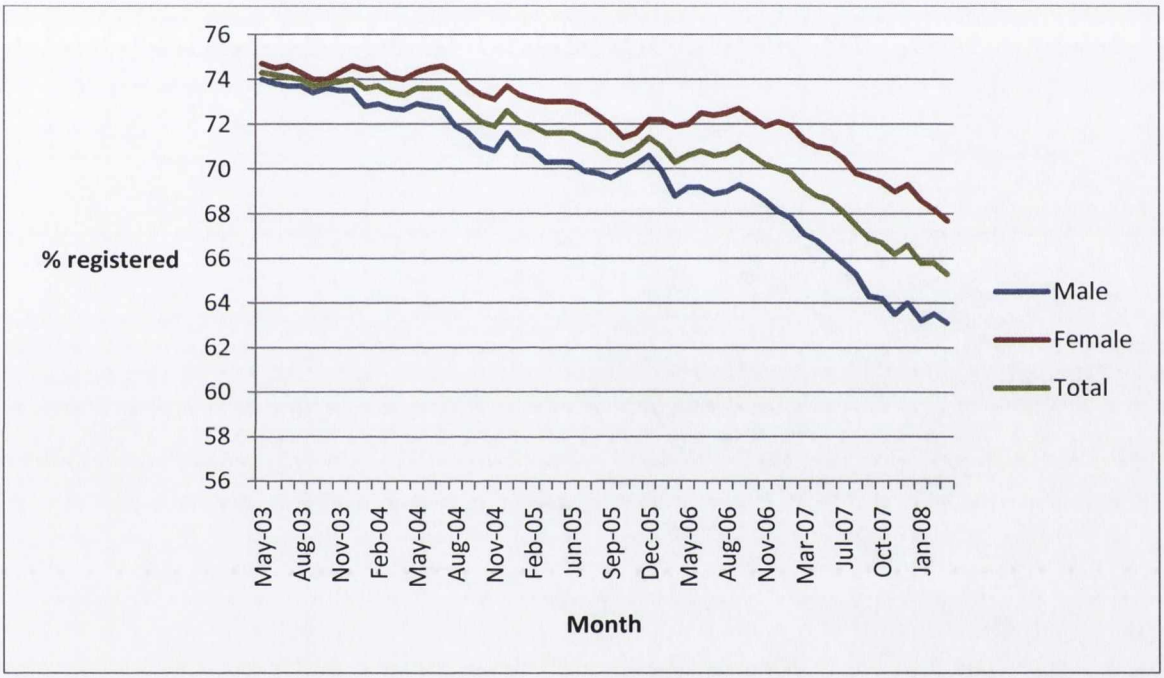
7.3.4 Changes in registration 2003/04 – 2007/08

This analysis was undertaken to identify if any of the relationships in the pooled analysis above varied when data were examined for individual years 2003/04 and 2007/08. This allows for the possibility of the child asserting independence and contributing to dental registration through dental attendance decisions.

While no significant inequalities were observed with respect to gender and dental registration in 2003/04, in 2007/08 females had significantly greater mean registration than males, 8.72 months compared to 8.20 months respectively. A clear

divergence of male and female registration can be witnessed in Figure 7.3 which displays the percentage of males and females registered monthly, 2003/04 – 2007/08; in May 2003 male and female registration rates were 74% and 74.7% respectively but by March 2008, these rates had decreased to 63.1% for males and 67.7% for females (figure 7.3).

Figure 7.3: Percentage of sample registered monthly across 2003/04 - 2007/08 (13,564 adolescents in NILS)



Another change which was observed was that those with one sibling had significantly higher mean dental registration in 2003/04 of 9.32 months compared to adolescents who were an only child, 8.87 months, however, by 2007/08 this result was only borderline significant.

A general observation which can be made is that average registration fell across all demographics during this time from 74.3% in May 2003 to 65.3% in March 2008. Table 7.3 also confirms this fall in dental registration; while adolescents were registered for an average of 8.14 (8.07, 8.21) months in 2003/04, in 2007/08 this figure had fallen to 7.38 (7.30, 7.46) and differences were significantly different

($p<0.001$). This supports H1 in hypothesis one, there exists a difference in dental registration between younger and older adolescents.

7.4 Discussion

The purpose of this analysis was to empirically test a number of economic hypotheses proposed to explain investment in dental health care.

7.4.1 Benefits of dental health care

The economic model in chapter 5 proposed differences in dental health investment may exist due to differences in the benefits to be accrued from such investments. The model proposed benefits were likely to vary according to parental income (as proxied by HRP NS-SEC) and gender.

This study found those adolescents with a HRP of higher NS-SEC had significantly greater mean dental registration (months) and on average, had less breaks in their dental registration than those adolescents with a HRP of lower NS-SEC. They were also more likely to be registered across the entire 2003/04 – 2007/08 period and less likely to not have registered at all across the entire period. Specifically, adolescents with a professional HRP had higher dental registration rates and fewer breaks in registration compared to those with a HRP at the bottom of the NS-SEC scale: semi-routine, routine and never worked/ long-term unemployed. These findings are consistent with a previous study (156). Registration permits access to publicly funded care, these results therefore imply access to GDP dental services is lower amongst lower social classes. Although some adolescents from lower social classes may have access to care via a community dentist, without actually having to register with a GDP, numbers treated on these grounds are very low. The main aim of the community dentist is to treat those with special needs and those requiring general anaesthetic or sedation for anxiety/ behavioural problems. In 2006, the community dental service employed 64 WTE dentists while the GDS employed 557 WTE

dentists. Therefore, access to dental services is most likely lower amongst those from lower social classes.

As explained in the economic model presented in section 5.4, within this study, HRP NS-SEC may in part act as a proxy for income. The model proposed that due to the utility gained from health, in terms of both healthy time and income, higher social classes would likely invest more in their dental healthcare. In his human capital model, Grossman (21) noted that the higher earners in society had a greater demand for health. Grossman rationalized this in that health determines the amount of time available for market and nonmarket activities. An increase in health therefore reduces time lost from these activities. Although within this model, it is NS-SEC and therefore the income of the HRP being proxied, the same principle will apply as bad oral health amongst adolescents resulting in for example lost school days will also impact on parental time. Income is also likely to be a function of health, therefore sustaining or aesthetically improving oral health will be important for higher earners. The HRP, acting on the adolescent's behalf may see investing in adolescents' oral health (or perhaps more correctly, ensuring the child remains registered so that investment in oral health can occur) as a long-term investment for the child. Similar NS-SEC relationships were witnessed in 2003/04 and 2007/08 indicating the increase in autonomy did not have different effects with regard to NS-SEC groups.

Access to dental treatments (including preventive dentistry), gained through dental registration may explain why increased registration levels are witnessed for professionals in comparison to those at the bottom of the social scale. Within this healthcare system, as adolescents are deregistered after 15 months of no contact with a dentist, maintaining registration with a dentist and fewer breaks in registration are related to more frequent contact with a dentist. This frequent contact helps to maintain good oral health; the dentist is afforded an opportunity to provide valuable preventive advice and cleaning, and treat early e.g. fissure sealants.

Females displayed higher mean registration and on average fewer breaks in registration than males. Females were also more likely to remain registered throughout the entire period and less likely not to have been registered at all. Higher dental registration amongst females was proposed in the model in 5.4. This is thought

to be attributed to that females derive higher utility from oral health as they perceive society places more pressure on them to look attractive. Oral health can be maintained or improved (for example by orthodontic use[22]) by registering with a dentist and keeping up this registration by visiting a dentist. This more regular attendance pattern amongst females has been shown in previous studies (52, 111).

Interestingly, the inequality in dental registration between genders did not exist at the beginning of the study when the adolescents were aged 11-13 years old but did exist when the adolescents were 15-17 years old. This suggests gender inequalities in dental registration may be the result of increased autonomy. At the beginning of the study, children are influenced to a much larger degree by their parents who it would appear make no distinction in access to dental care between the gender of their children. However, this influence weakens as we move across the adolescent years. The result confirms that of previous studies, that females are more likely to seek dental treatment than males.

The economic model proposed in chapter 5 predicted differences in the rate at which net benefits of investing in dental healthcare are discounted may explain variations in registration for dental services. These differences in discount rate may be due to time preference which was predicted to vary according to factors related to adolescent age, HRP education and community background.

This study found the duration of registration was significantly lower when adolescents were aged 15-17 years compared to 11-13 years. The economic model in chapter 5 predicted that dental registration may differ between older and younger adolescents due to a change in parental influence across these time periods. Parents are more likely to influence younger adolescents' decisions while older adolescents are more likely to make their own decisions and both will have different rates of time preference. With their greater life experience, parents may be more future orientated and hence more likely to invest in their children's oral health now due to higher perceived future benefits reflected in a lower discount rate. In contrast to this, adolescents will not have the same life experience and are more likely to focus on the

[22] Within this dataset, orthodontic treatment cost £2, 725, 781, which accounted for 45% of overall expenditure. Females were almost 47% more likely than males to receive orthodontic treatment.

present than the future. Adolescents are therefore less likely to make investments in oral health as they discount the future more highly than adults and this may explain why lower dental registration is witnessed amongst older adolescents.

This study identified highest educational attainment of the HRP was directly related to dental registration; GCSEs or no qualifications led to reduced mean number of months registered in comparison to degree or above. The analysis on breaks in dental registration confirmed GCSEs or no qualifications were associated with an increase in the average number of dental breaks compared to degree and above. Those adolescents whose HRP was less qualified were also more likely to have had no registration at all and less likely to have been registered for the entire duration. Educational disparities witnessed in 2003/04 remained in 2007/08.

The economic model in 5.4 proposed that those who are more educated are likely to have a lower rate of time preference and therefore more likely to invest in their dental health. Although it is the education of the HRP being observed, the HRP most likely acts as an agent for the adolescent. That dental registration was higher amongst adolescents with a more highly educated HRP indicates greater access to dental services through greater dental attendance. The main opportunity cost associated with dental attendance is time (treatments are free); those who are more highly educated are investing greater time in their dental health care in return for higher future benefits.

The economic model also proposed discount rates may vary according to community background and this may affect dental registration. Catholic adolescents had significantly lower mean registration and more breaks in registration than Protestants. Catholics were also less likely than Protestants and other community backgrounds to remain fully registered throughout the entire period. The economic model presented proposed lower dental registration rates would be witnessed in Catholics. Previous studies conducted in Northern Ireland found that Catholics were more likely to engage in behaviour which could adversely affect their health such as

drinking, smoking and poor diet[23].(149) This relationship has also been found to apply to adolescents; a greater proportion of adolescents attending Catholic schools were smokers in comparison to those attending Protestant schools (157). These studies, unlike this study, were not able to rule out the observed relationship was due to social disadvantage[24]. As a result of adverse health behaviour and therefore a higher rate of time preference, Catholics are likely to have a higher discount rate of investment in oral health. Therefore, Catholics are likely to invest less in dental health care and as a consequence, display lower levels of dental registration. It is also possible community background is reflecting some aspects of income which have not been fully absorbed in the NS-SEC variable.

7.4.2 Barriers in accessing dental health care

Barriers which exist in obtaining access to dental care may further explain the observed relationship between dental registration and SES. Although all adolescents within Northern Ireland are entitled to free dental care, costs will still be encountered in travelling to a dental surgery, in terms of relative cost, this will be significantly higher for those from the lowest social classes. Lower social classes are also more likely to lack the necessary transportation to attend dental appointments.

Disparities in dental registration witnessed according to family size and structure may also be related to barriers associated with money but also time costs of accessing a dentist.

Adolescents living in unmarried families (co-habiting or lone parent) had lower and similar levels of mean dental registration while those in lone parent families had on average more breaks in registration. Those living in unmarried families were also more likely to have no period of registration and this likelihood was significantly higher for those in cohabiting families. Those living in unmarried families were also less likely to be registered for the entire period.

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[23] This study found Protestants were half as likely as Catholics to have smoked at some time in their lives; this association remained after controlling for educational qualifications. Protestant men were half as likely to be heavy drinkers as Catholic men.

[24] O'Reilly and Stevenson identified the greater the percentage of Catholics in an area, the greater the level of disadvantage; this relationship was observed in respect of the variables unemployment, long-term unemployment, children in non-earner households, educational attainment and income support.

The observed relationship amongst lone parent families may also be explained by pressure on parental time. Household, working and parental activities normally divided across two parents now fall mainly on the single parent putting added pressures on time and organisation. The increased burden on the single parent may explain lower dental registration and an increase in the number of breaks in dental registration. However, amongst lone parent families this outcome could also be related to income as income will generally be lower when there is only one parent in comparison to two and this would not have been detected in HRP NS-SEC examined previously. Therefore, reduced dental registration as observed for lower incomes, may also apply here to lone parent families.

Co-habiting families also had reduced levels of registration and this may be explained in that instability can exist as cohabiting unions are more likely to be short-lived and hence we may be seeing the effects of single parenting (158) or of living with a non-biological parent. A non-biological parent may express less interest in the children as this is not their own offspring and may also be more demanding of their partner's time than would be the case in a marriage. This may explain why adolescents in co-habiting families were significantly more likely than both those living in lone parent families and those living in married families to have no period of registration. This may then affect the amount of parenting a child receives and hence the likelihood of dental registration is reduced. It is conceded though that this is speculative.

Adolescents living with one sibling were recorded as having borderline significantly greater registration than adolescents living in single child families while adolescents living with three (borderline) or four siblings were found to have significantly less registration. This can be explained through economies of scale. While dental registration in two child families appears to be explained by economies of scale, four or five child families shows evidence of diseconomies of scale. Assuming within the two child families, dental registration and therefore subsequent dental attendance takes place at the same dentist, cost and time required per child will on average be lower than for a single child. Often the mode of transport will have a fixed cost e.g. car or taxi and therefore, cost per child is reduced. Parental time consumed per child

will be significantly lower for two children than for one as often a majority of time required in dental visiting is spent travelling and waiting.

However, average cost per child decreases only to a certain point, after which average cost will begin to rise again. It appears we are witnessing this in the case of four or five child families. Many modes of transport, taxi, car, safely allow for a maximum of four or five people, after which it is necessary to utilize another taxi or car increasing average cost per child from a minimum point and increasing overall cost to the parent compared to that for transporting a single child to the dentist. Also, many dental appointments take place during or after school hours, four or five children from one family may well attend different schools making dental registration and subsequent attendance to remain registered more troublesome for parents perhaps explaining greater breaks in registration in families with four children.

A further alternative explanation in relation to lower social classes is that they may be more likely to encounter problems in registering with a NHS dentist creating further barriers in dental registration. Most dentists operating within Northern Ireland (around 90%) work for the General Dental Service and are independently contracted within existing Health and Social Services Boards to work from privately owned and maintained premises(159). This entitles these dentists to carry out both NHS dentistry and private dentistry. Although all adolescents are entitled to free NHS dental health care, this is not the case for adults and a considerable proportion of adult dental treatment is carried out in the private sector[25]. Often, parents will attend the same dental surgery as their children. Dentists, like other economic agents are seeking to maximize profit and may therefore favour adolescents from wealthier families whose parents have the ability to pay for private, and often expensive, dental treatments. In order to prove this, patterns of use among adults in the family would be required although information of this nature would be difficult to obtain.

[25] General dental practitioners spent 86% of their working week in health Service dentistry and 14% doing private dentistry in November 2004 (Primary Dental Care Strategy, 2006).

7.5 Conclusion

This study of dental registration has found, with the use of the economic model developed in 5.4, inequalities in access to dental treatments to exist across a number of demographics including socio-demographics. 'The NHS is founded on the principles of access being equal for all, and services being free at the point of use and based on clinical need, not ability to pay'. (18) That dental registration is lower amongst those from lower social backgrounds, who have been discovered previously as having increased need for care[26], suggests the current system is not successfully achieving this principle.

Unregistered dental periods highlight periods at risk of developing poorer oral health as not only does the individual not have ongoing access to dental treatments but also, no access to preventive dentistry. As was mentioned previously, those who are not registered with a GDP, may still obtain access to dental care via a community dentist and a small number from this study would have done so. However, it is expected this type of contact would be more sporadic with adolescents experiencing dental problems attending for treatment. As dental registration grants access to dental care and ongoing dental registration shows dental care is being availed of, those with lower registration utilise dental services less. This allows the dentist less opportunity to prevent and treat dental decay putting those with lower utilisation at greater risk of poorer oral health.

These findings support the use of this economic model in the development of policy in relation to dental registration. It would appear costs and benefits of dental care combined with time preference interact with a number of demographics and impact on adolescent dental registration. Based on these findings, policy instruments can be devised to impact on inequalities in dental registration and will be discussed in chapter nine.

[26] The 2003 Children's Dental health Survey found amongst 15 year olds, 33% from the lowest social class had untreated decay, compared to 23% from the highest social class.

The next chapter will further examine use of dental services across the same demographics/ socio-demographics, this time concentrating on variations in treatment consumption.

Table 7.1: Multivariate OLS regression of months registered and breaks in registration with dentist by HRP NS-SEC, HRP education, gender, family type, no. siblings and community background (2003/04 - 2007/08)

	Months registered*				Breaks in registration			
Independent variable	**No.**	**Mean no. months registered**	**Difference in means**	**P value**	**No.**	**Mean no. breaks**	**Difference in means**	**P value**
HRP NS-SEC				**0.0000**				**0.0013**
Professional	3,963	43.08 (41.84, 44.31)	0.00		3,826	0.91 (0.85, 0.98)	0.00	
Intermediate	1,081	42.58 (41.51, 43.65)	-0.50 (-1.57, 0.57)	0.359	1,027	0.90 (0.84, 0.96)	-0.01 (-0.07, 0.05)	0.818
Self-employed	2,156	42.97 (42.10, 43.84)	-0.11 (-0.98, 0.76)	0.803	2,069	0.95 (0.90, 1.00)	0.04 (-0.01, 0.09)	0.150
Semi-routine	3,239	**40.28 (39.47, 41.08)**	**-2.80 (-3.61, -2.00)**	**0.000**	3,048	**0.97 (0.92, 1.01)**	**0.06 (0.01, 0.10)**	**0.009**
Routine	2,249	**39.20 (38.24, 40.15)**	**-3.88 (-4.84, -2.93)**	**0.000**	2,079	**1.00 (0.95, 1.05)**	**0.09 (0.04, 0.14)**	**0.000**
Never worked/ long-term unemployed	876	**37.20 (35.82, 38.58)**	**-5.88 (-7.26, -4.50)**	**0.000**	797	**1.02 (0.95, 1.09)**	**0.11 (0.04, 0.18)**	**0.002**
HRP education				**0.0000**				**0.0000**
Degree and above	2,310	43.08 (41.84, 44.31)	0.00		2,241	0.91 (0.85, 0.98)	0.00	
Two or more a-levels	802	42.16 (40.98, 43.35)	-0.92 (-2.10, 0.27)	0.129	769	0.95 (0.88, 1.02)	0.04 (-0.03, 0.11)	0.267
GCSEs	5,076	**40.75 (39.97, 41.53)**	**-2.33 (-3.11, -1.55)**	**0.000**	4,859	**1.02 (0.97, 1.07)**	**0.11 (0.06, 0.16)**	**0.000**
No qualifications	5,376	**37.73 (36.84, 38.62)**	**-5.35 (-6.24, -4.46)**	**0.000**	4,977	**1.06 (1.01, 1.11)**	**0.15 (0.10, 0.20)**	**0.000**
Gender				**0.0000**				**0.0369**
Male	6,994	43.08 (41.84, 44.31)	0.00		6,584	0.91 (0.85, 0.98)	0.00	
Female	6,570	**44.48 (43.96, 45.00)**	**1.40 (0.88, 1.92)**	**0.000**	6,262	**0.88 (0.85, 0.91)**	**-0.03 (-0.06, 0.00)**	**0.037**
Family type				**0.0000**				**0.000**
Married	10,050	43.08 (41.84, 44.31)	0.00		9,602	0.91 (0.85, 0.98)	0.00	
Co-habiting	461	**37.87 (36.29, 39.45)**	**-5.21 (-6.79, -3.63)**	**0.000**	414	0.99 (0.91, 1.07)	0.08 (0.00, 0.16)	0.064
Lone parent	3,053	**38.26 (37.52, 39.00)**	**-4.82 (-5.56, -4.08)**	**0.000**	2,830	**1.05 (1.01, 1.09)**	**0.14 (0.10, 0.18)**	**0.000**
Siblings				**0.0000**				**0.0002**
0	1,117	43.08 (41.84, 44.31)	0.00		1,041	0.91 (0.85, 0.98)	0.00	
1	4,554	44.12 (43.04, 45.19)	1.04 (-0.04, 2.11)	0.059	4,365	0.89 (0.84, 0.95)	-0.02 (-0.07, 0.04)	0.537
2	4,529	42.73 (41.64, 43.82)	-0.35 (-1.44, 0.74)	0.532	4,298	0.95 (0.90, 1.01)	0.04 (-0.01, 0.10)	0.149
3	3,072	41.96 (40.81, 43.12)	-1.12 (-2.27, 0.04)	0.058	2,880	**0.98 (0.92, 1.04)**	**0.07 (0.01, 0.13)**	**0.024**
4	292	**40.11 (37.91, 42.30)**	**-2.97 (-5.17, -0.78)**	**0.008**	262	0.89 (0.78, 1.01)	-0.02 (-0.13, 0.10)	0.790
Community				**0.0000**				**0.0000**

background								
Catholic	6,741	43.08 (41.84, 44.31)	0.00		6,372	0.91 (0.85, 0.98)	0.00	
Protestant	6,230	**44.88** **(44.33, 45.43)**	**1.80** **(1.25, 2.35)**	**0.000**	**5,917**	**0.78** **(0.75, 0.81)**	**-0.13** **(-0.16,-0.10)**	**0.000**
Other	593	42.84 (41.49, 44.19)	-0.24 (-1.59, 1.11)	0.727	**557**	**0.81** **(0.74, 0.89)**	**-0.10** **(-0.17, 0.02)**	**0.008**

* Reports on robust standard errors

Table 7.2: Multivariate logistic regression for no registration and full registration 2003/04 - 2007/08 (13,564 adolescents in NILS)

		No registration (0 months)		Full registration (54 months)	
Independent variable	**No.**	**Odds ratio**	**P value**	**Odds ratio**	**P value**
HRP NS-SEC			**0.0023**		**0.0000**
Professional	3,963	1.00		1.00	
Intermediate	1,081	1.26 (0.90, 1.77)	0.176	1.09 (0.93, 1.28)	0.307
Self-employed	2,156	0.88 (0.65, 1.19)	0.417	0.99 (0.87, 1.14)	0.914
Semi-routine	3,239	1.26 (0.97, 1.62)	0.080	**0.80 (0.71, 0.91)**	**0.001**
Routine	2,249	**1.47 (1.12, 1.93)**	**0.005**	**0.70 (0.60, 0.82)**	**0.000**
Never worked/ long-term unemployed	876	**1.50 (1.07, 2.10)**	**0.019**	**0.49 (0.38, 0.64)**	**0.000**
HRP education			**0.0000**		**0.0000**
Degree and above	2,310	1.00		1.00	
Two or more a-levels	802	1.23 (0.80, 1.90)	0.343	0.86 (0.71, 1.03)	0.104
GCSEs	5,076	1.21 (0.89, 1.65)	0.213	**0.69 (0.61, 0.78)**	**0.000**
No qualifications	5,376	**1.95 (1.43, 2.67)**	**0.000**	**0.56 (0.49, 0.64)**	**0.000**
Gender			**0.0026**		**0.0033**
Male	6,994	1.00		1.00	
Female	6,570	**0.79 (0.68, 0.92)**	**0.003**	**1.13 (1.04, 1.23)**	**0.003**
Family type			**0.0000**		**0.0000**
Married	10,050	1.00		1.00	
Co-habiting	461	**2.03 (1.47, 2.80)**	**0.000**	**0.67 (0.52, 0.87)**	**0.002**
Lone parent	3,053	**1.33 (1.11, 1.61)**	**0.003**	**0.54 (0.47, 0.61)**	**0.000**
Siblings			**0.0006**		**0.0000**
0	1,117	1.00		1.00	
1	4,554	**0.69 (0.52, 0.91)**	**0.008**	1.14 (0.97, 1.35)	0.120
2	4,529	0.86 (0.66, 1.14)	0.292	0.94 (0.79, 1.11)	0.471
3	3,072	1.05 (0.79, 1.40)	0.736	0.87 (0.73, 1.05)	0.142
4	292	1.17 (0.74, 1.86)	0.497	0.69 (0.43, 1.09)	0.110
Community background			0.3422		**0.0000**
Catholic	6,741	1.00		1.00	
Protestant	6,230	1.04 (0.88, 1.21)	0.673	**1.56 (1.43, 1.71)**	**0.000**
Other	593	1.32 (0.92, 1.89)	0.132	**1.38 (1.13, 1.70)**	**0.002**

Table 7.3: Mean no. months registered with dentist by HRP NS-SEC, HRP education, gender, family type, no. siblings and community background 2003/04 and 2007/08 - multivariate analyses (13,564 adolescents in NILS)

		2003/04*			2007/08*		
Independent variable	**No.**	**Mean no. months registered (/11)**	**Difference in means**	**P value**	**Mean no. months registered (/11)**	**Difference in means**	**P value**
HRP NS-SEC				**0.0000**			**0.0000**
Professional	3,963	8.87 (8.54, 9.20)	0.00		8.20 (7.85, 8.55)	0.00	
Intermediate	1,081	8.66 (8.37, 8.94)	-0.21 (-0.50, 0.07)	0.136	8.05 (7.75, 8.35)	-0.15 (-0.45, 0.15)	0.327
Self-employed	2,156	8.91 (8.68, 9.14)	0.04 (-0.19,0.27)	0.734	8.16 (7.91, 8.41)	-0.04 (-0.29, 0.21)	0.745
Semi-routine	3,239	**8.40 (8.19, 8.62)**	**-0.47 (-0.68, -0.25)**	**0.000**	**7.57 (7.34, 7.80)**	**-0.63 (-0.86, -0.40)**	**0.000**
Routine	2,249	**8.05 (7.80, 8.31)**	**-0.82 (-1.07, -0.56)**	**0.000**	**7.49 (7.22, 7.76)**	**-0.71 (-0.98, -0.44)**	**0.000**
Never worked/ long-term unemployed	876	**7.83 (7.45, 8.21)**	**-1.04 (-1.42, -0.66)**	**0.000**	**6.87 (6.48, 7.25)**	**-1.33 (-1.72, -0.95)**	**0.000**
HRP education				**0.0000**			**0.0000**
Degree and above	2,310	8.87 (8.54, 9.20)	0.00		8.20 (7.85, 8.55)	0.00	
Two or more a-levels	802	8.72 (8.42, 9.02)	-0.15 (-0.45, 0.15)	0.335	8.02 (7.68, 8.37)	-0.18 (-0.52, 0.17)	0.312
GCSEs	5,076	**8.39 (8.18, 8.59)**	**-0.48 (-0.69, -0.28)**	**0.000**	**7.74 (7.51, 7.96)**	**-0.46 (-0.69, -0.24)**	**0.000**
No qualification	5,376	**7.81 (7.58, 8.05)**	**-1.06 (-1.29, -0.82)**	**0.000**	**7.08 (6.82, 7.33)**	**-1.12 (-1.38, -0.87)**	**0.000**
Gender				0.2089			**0.0000**
Male	6,994	8.87 (8.54, 9.20)	0.00		8.20 (7.85, 8.55)	0.00	
Female	6,570	8.96 (8.82, 9.10)	0.09 (-0.05, 0.23)	0.209	**8.72 (8.57, 8.87)**	**0.52 (0.37, 0.67)**	**0.000**
Family type				**0.0000**			**0.0000**
Married	10,050	8.87 (8.54, 9.20)	0.00		8.20 (7.85, 8.55)	0.00	
Co-habiting	461	**7.57 (7.13, 8.01)**	**-1.30 (-1.74, -0.86)**	**0.000**	**7.45 (7.03, 7.88)**	**-0.75 (-1.17, -0.32)**	**0.001**
Lone parent	3,053	**7.80 (7.60, 8.00)**	**-1.07 (-1.27, -0.87)**	**0.000**	**7.3 (7.09, 7.50)**	**-0.90 (-1.11, -0.70)**	**0.000**
Siblings				**0.0001**			**0.0001**
0	1,117	8.87 (8.54, 9.20)	0.00		8.20 (7.85, 8.55)	0.00	
1	4,554	**9.32 (9.03, 9.61)**	**0.45 (0.16, 0.74)**	**0.002**	8.48 (8.17, 8.78)	0.28 (-0.03, 0.58)	0.072
2	4,529	9.08	0.21	0.150	8.14	-0.06	0.701

		(8.79, 9.38)	(-0.08, 0.51)		(7.83, 8.45)	(-0.37, 0.25)	
3	3,072	8.93 (8.62, 9.24)	0.06 (-0.25, 0.37)	0.710	8.05 (7.73, 8.38)	-0.15 (-0.47, 0.18)	0.368
4	292	8.60 (7.98, 9.21)	-0.27 (-0.89, 0.34)	0.384	7.65 (7.04, 8.14)	-0.55 (-1.16, -0.06)	0.078
Community background				**0.0000**			**0.0011**
Catholic	6,741	8.87 (8.54, 9.20)	0.00		8.20 (7.85, 8.55)	0.00	
Protestant	6,230	**9.34** **(9.20, 9.49)**	**0.47** **(0.33, 0.62)**	**0.000**	**8.49** **(8.33, 8.65)**	**0.29** **(0.13, 0.45)**	**0.000**
Other	593	8.94 (8.58, 9.30)	0.07 (-0.29, 0.43)	0.708	8.26 (7.88, 8.64)	0.06 (-0.32, 0.44)	0.760
Total**	**13,564**	**8.14** **(8.07, 8.21)**	**n/a**	**n/a**	**7.38** **(7.30, 7.46)**	**n/a**	**n/a**

* reports on robust standard errors

** two tailed t-test on the difference of means between 2003 and 2007 indicated a difference in means of 0.76 (0.66, 0.87), $p < 0.001$

8 Inequalities in expenditure on dental treatments within the NHS

8.1 Introduction

The NHS aims to promote equal access for equal need within healthcare provision. This ultimately extends to NHS dentistry. However, previous studies have identified patients from deprived backgrounds received different healthcare than those from more affluent backgrounds. This inequality has also been witnessed in dental healthcare as noted in chapter 4.

The aim of this chapter is to investigate dental expenditure and treatment allocation. This study provided an opportunity to explore the relationship between SES (as measured by HRP NS-SEC and HRP education) and dental provision/ expenditure across the period 2003/ 2004 – 2007/ 2008 and a number of other demographics. The economic model outlined in section 5.4 will be further tested here.

8.2 Methods

8.2.1 Statement of dental remuneration

The Statement of dental remuneration[27] is produced annually and specifies treatments that may be carried out within the NHS and the reimbursement to dentists for doing so.

The dataset described in 6.1 was used for analyses undertaken here. However, those 718 adolescents who did not make use of dental services during this time were excluded leaving a sample of 12,846 adolescents within these analyses. It would not have been appropriate to include adolescents who did not make use of dental services during this time as it was not possible for them to have received treatment.

[27] The most recent SDRs may be viewed at http://www.centralservicesagency.com/display/statement_of_dental_remunera

8.2.2 Variables

As explained previously all adolescents within this dataset were eligible to register with a dentist who then received a monthly registration fee for the duration of the registration. Certain treatments may then have been provided (according to the SDR). Treatments were analysed in the following ways:

1. Conservative treatment in three separate areas:
    - Fillings
    - Endodontic treatment
    - Other conservative (porcelain veneers, inlays and crowns, bridges)
2. Orthodontics
3. Extractions
4. Other treatment (preventive care, periodontal treatment, prostheses, obturators and other (non-orthodontic) appliances)

Within the NHS, conservative treatment, orthodontic treatment and extractions are the main areas where work is undertaken in adolescents. It was decided to look at sub categories of conservative treatment as different patterns of use may be witnessed between say fillings and more serious treatments such as endodontics. Treatments other than conservative, orthodontics and extractions were grouped together as none of these treatments would be expected to be particularly common amongst adolescents for example periodontal treatment and prostheses. Preventive care was also grouped with other treatment as, although the SDR contains preventive care treatments, few are not provided free of charge to adolescents[28]. Once again, only expenditure on GDP treatments was considered, the suspected implications of treatment delivery by the community and hospital dental services are however discussed.

In the UK, orthodontic treatment is often accompanied by extractions. Within the extractions analyses undertaken here (table 8.3) orthodontic treatment was controlled for so that disparities in extractions for reasons other than orthodontics may be

[28] Since 2006 preventive fissure sealants have been made available free of charge in second molar teeth in children under the age of 13 and to unfilled third molar teeth within two years of their eruption however, a very small amount were provided to this study population.

investigated. It would not be appropriate to consider teeth extracted for orthodontic reasons alongside teeth extracted for other reasons such as decay as the former is essentially aesthetically improving oral health whereas the latter indicates teeth are in a state of disrepair and the extraction may actually decrease the aesthetic appearance of teeth. Orthodontic use was a binary variable (equal to one if orthodontic treatment had been administered and equal to zero otherwise).

Within each treatment, two outcome variables were measured, firstly, treatment receipt (as a binary variable) and secondly, expenditure (as a continuous measure). Analysis of treatment receipt allows comparisons of numbers receiving each treatment whereas analysis of expenditure gives an indication of treatment intensity. Both measures are important as the first indicates if the treatment was done and the latter the average intensity of use.

Covariates

Two variables commonly used to represent SES are included within these analyses; NS-SEC and highest educational attainment of the household reference person. However, as discussed within the economic model (5.4), these variables have been used within these analyses to represent specific factors of SES. HRP NS-SEC acts as a proxy for income and HRP highest educational attainment reflects time preference. Gender, family structure, family size and community background have also been included.

As dental attendance is thought to affect dental treatments received (76), and the previous chapter highlighted social inequalities in dental registration, it was important to allow for dental registration when investigating treatment consumption. This is a way of controlling for exposure to dentists on the premise that greater exposure or different patterns of exposure may affect the type and intensity of care. Dental registration was captured in two ways: as a categorical variable of months registered and a categorical variable representing the number of breaks in registration. Months registered is a good indicator of dental attendance as those who fail to attend a dentist within a fifteen month period are automatically deregistered. Breaks in registration indicate sporadic dental attendance and are more likely to be representative of those attending with trouble compared to those with no breaks in

registration. This therefore allows investigation of inequalities in treatment receipt after controlling for dental attendance patterns.

8.2.3 Hypotheses

This chapter also examines specific hypotheses in relation to orthodontic treatments. Hypotheses three, six and eight investigate disparities in the receipt of orthodontic treatment according to HRP education, HRP NS-SEC and gender respectively. Although the investment model predicts orthodontic treatment will be higher in those of more highly educated HRP, those with higher income HRP and females, as previously described the reverse cannot be ruled out so therefore hypotheses to be tested do not stipulate a direction.

8.2.4 Statistical methods

The first stage of this chapter makes use of concentration indices and concentration curves in a preliminary analysis investigating social inequalities in dental healthcare expenditure. This procedure is fully described in 6.2.4. Concentration indices were calculated for grouped-data ranked by increasing NS-SEC[29]. Within the first set of concentration indices (figure 8.4) figures are unadjusted whereas within the second set of concentration indices (figure 8.5), figures have been adjusted for all other demographics/ socio-demographics (as per tables 8.1 to 8.6).

The second stage of this chapter makes use of multivariate logistic regression for each of the treatments (orthodontics, extractions, conservative (including separate analyses for fillings and endodontics) to determine inequalities in relation to receipt, as a binary variable, of each of these treatments.

Next, linear regressions were employed using average expenditure on various dental services as the outcome variables. This procedure is fully explained in 6.2. The large number of observations within these analyses means that the dependent variable becomes approximately normally distributed under the central limit theorem.

[29] NS-SEC was as for all other analyses except intermediate was combined with self-employed while semi-routine was combined with routine. This is the correct groupings to use when a hierarchy is assumed as per ONS guidelines.

Amongst the covariates (within both multivariate logistic regression and linear regression), dummy variables were created within each category, to allow comparison to the reference category (Appendix 6). Demographics/ socio-demographics (as discussed in the economic model (section 5.4)) were included within the analyses undertaken here while dental registration and breaks in registration (as described above) were controlled for. In addition, within extractions analyses, receipt of orthodontic treatment, as a binary variable was controlled for. Including all variables with a potential to explain the dependent variable helps ensure against omitted variable bias and avoids a poorly specified model with potentially biased estimated parameters. Models were tested for heteroscedasticity using white's test (151) and those which tested positively were re-run to report on robust standard errors. Lastly, within logistic and OLS regressions, likelihood ratio tests were used to find the joint significance of groups of variables representing a particular concept.

8.3 Results

This study represented data on 12,846 adolescents (includes those from the dataset described in 6.1.5 minus those with no period of dental registration). The characteristics of this sample are shown in Appendix 6. Within this sample, males accounted for 51% of the population while almost half of the sample was Catholic. Almost three quarters of the adolescents lived within married families. NS-SEC of HRP revealed a majority were professionals or semi-routine, 29.8 % and 23.7% respectively. Highest educational attainment of HRP was GCSEs or no qualifications for over three quarters of adolescents. Around two thirds of adolescents had one or two siblings.

8.3.1 Dental expenditure

Some preliminary descriptive statistics were calculated on the total dental healthcare expenditure. From this sample of 12,846 adolescents, £6,109,463 expenditure was generated on dental treatments and registration (capitation payments) across the years 2003/04 – 2007/08. From figure 8.1 it can be seen a majority of this was spent on orthodontic treatment (45%), followed by registration payments (33%).

Conservative treatment accounted for 15% of this (13% fillings, 1% endodontics, 1% other), other treatments accounted for a further 5% and extractions for the remaining 2%.

Figure 8.1: Total dental expenditure (12,846 adolescents in NILS)

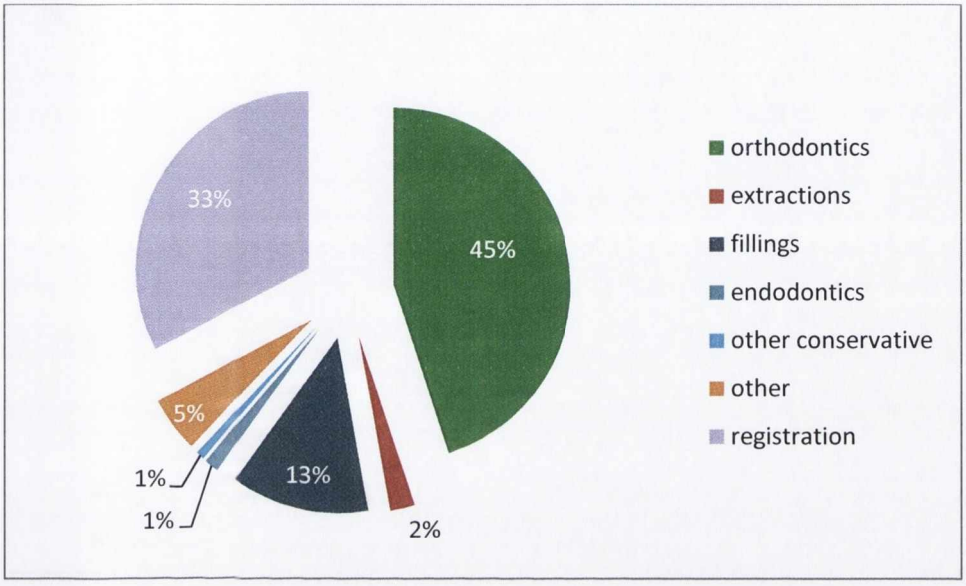
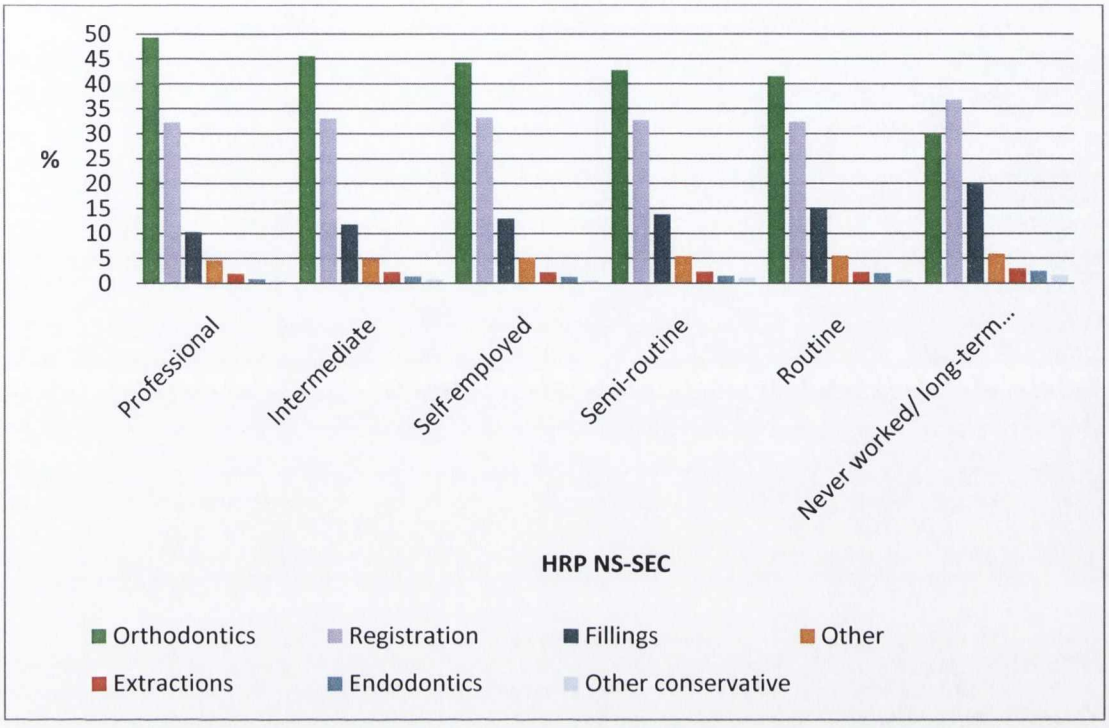


Figure 8.2 looks at expenditure within each NS-SEC category. Amongst all groups, except never worked/ long term unemployed, the highest expenditure was on orthodontic treatments and this figure was greatest amongst professionals who had 49.3% of their expenditure on orthodontics. Amongst never worked/ long term unemployed the highest expenditure was on registration and this accounted for 36.8% of total expenditure. An inverse relationship was witnessed between NS-SEC and percentage of expenditure on fillings; 10.3% for professionals compared to 19.9% for never worked/ long term unemployed.

Figure 8.2: Percentage expenditure on dental services by HRP NS-SEC (12,846 adolescents in NILS)



8.3.2 Results from concentration indices and regression analyses

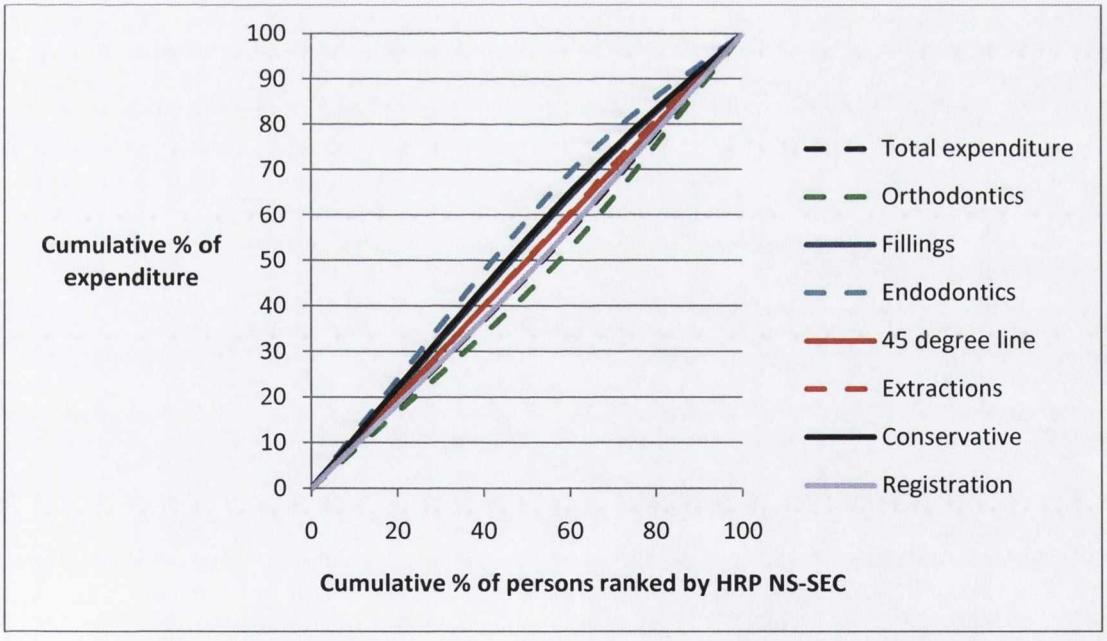
8.3.2.1 Social class

HRP NS-SEC

Figure 8.3 shows concentration curves for all dental treatments whilst figure 8.4 shows the related concentration indices. These preliminary results are not adjusted for any other demographics and do not control for dental registration. Total dental expenditure was more concentrated amongst adolescents with a HRP of higher NS-SEC for which the concentration index (CI) was 0.04 (0.03, 0.05). Expenditure on orthodontics and registration was also more concentrated amongst adolescents with a HRP of higher NS-SEC for which the CI's were 0.08 (0.06, 0.11) and 0.03 (0.03, 0.04) respectively. The concentration index for extractions was not statistically significant. All conservative treatments were more concentrated amongst adolescents with a HRP of lower NS-SEC with a CI of -0.06 (-0.09, -0.02)) while so were individual conservative treatments: fillings for which the CI was -0.04 (-0.07, -0.02) and endodontics for which the CI was -0.10 (-0.18, -0.03).

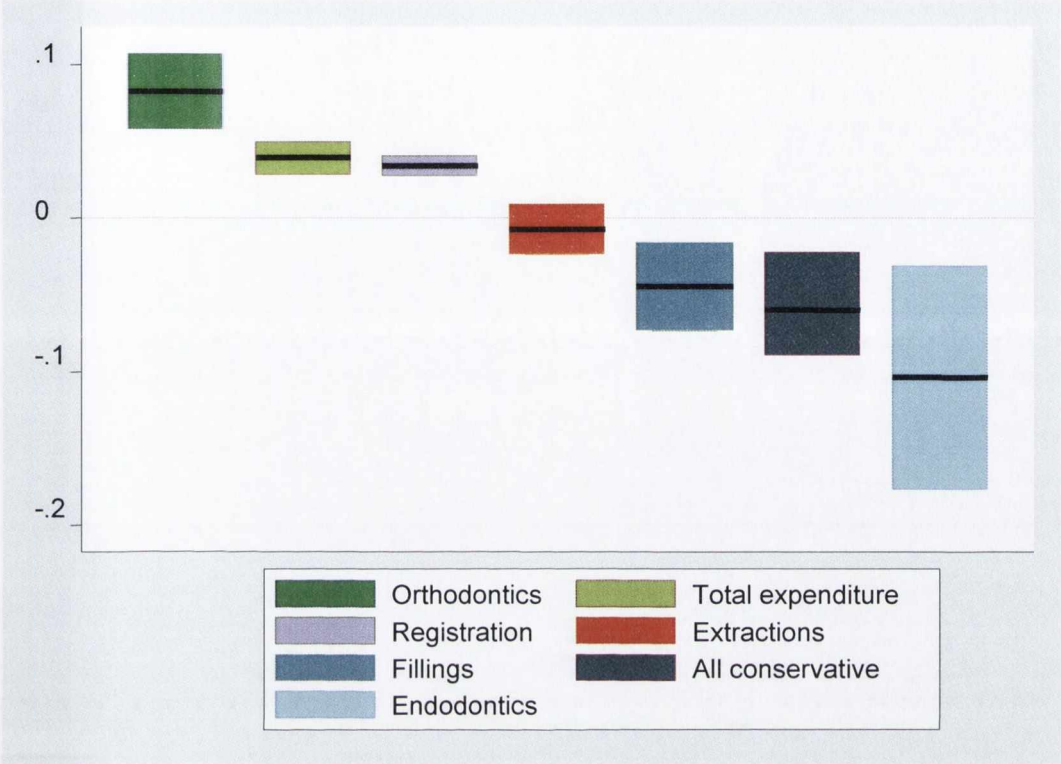
Figure 8.5 shows concentration indices after adjusting for all other factors; HRP education, gender, community background, family structure, family size, duration of registration and breaks in registration and in the case of extractions, orthodontics were also adjusted for. Total expenditure was slightly significantly more concentrated amongst those adolescents with a HRP of higher NS-SEC shown through a CI of 0.0037 (0.0005, 0.0069). Orthodontic treatment continued to be more concentrated amongst adolescents with a HRP of higher NS-SEC; CI 0.02 (0.01, 0.03). All conservative treatments continued to be more concentrated amongst adolescents with a HRP of lower NS-SEC, for which the CI was -0.04 (-0.05, -0.03), while so did individual conservative treatments: fillings for which the CI was -0.03 (-0.04, -0.03) and endodontics for which the CI was -0.12 (-0.22, -0.03). Extractions were now more concentrated amongst adolescents with a HRP of lower NS-SEC for which the CI was -0.03 (-0.06, -0.01).

Figure 8.3: Concentration curves for dental services (12,846 adolescents NILS)



Note that the extractions curve is almost identical to the 45 degree line. Conservative and fillings curves are almost identical.

Figure 8.4: Concentration indices for dental services, unadjusted (12,846 adolescents in NILS)



Dental service	Orthod-ontics	Total expend-iture	Regist-ration	Extra-ctions	Fillings	All conser-vative	Endod-ontics
Concentration Index	0.08***	0.04***	0.03***	-0.01	-0.04**	-0.06**	-0.10**
Lower 95% CI	0.06	0.03	0.03	-0.02	-0.07	-0.09	-0.18
Upper 95% CI	0.11	0.05	0.04	0.01	-0.02	-0.02	-0.03

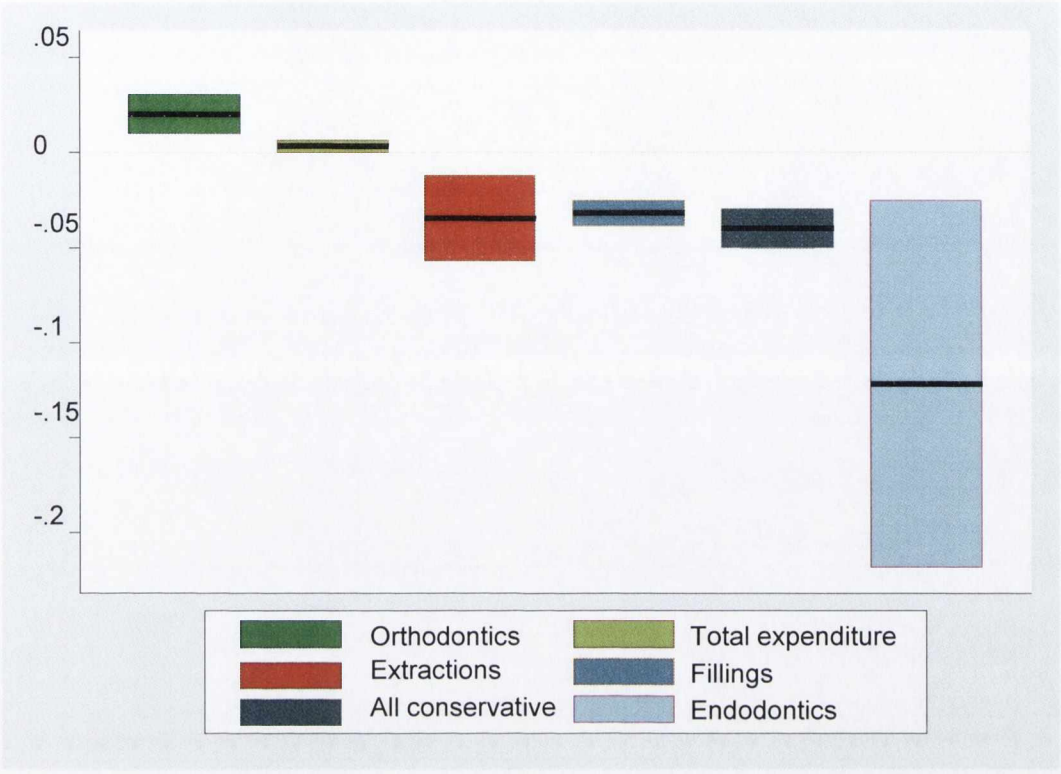
* P<0.05

** P<0.01

*** P<0.001

Concentration index represented for each item by black line, 95% confidence interval represented by coloured bar.

Figure 8.5: Concentration indices for dental services adjusted for other factors as per tables 8.1 to 8.6 (12,846 adolescents in NILS)



Dental service	Orthod-ontics	Total expend-iture	Extracti-ons	Fillings	All Conserva-tive	Endodont-ics
Concentration Index	0.02**	0.00*	-0.03**	-0.03***	-0.04***	-0.12*
Lower 95% CI	0.01	0.00	-0.06	-0.04	-0.05	-0.22
Upper 95% CI	0.03	0.01	-0.01	-0.03	-0.03	-0.03

* P<0.05

** P<0.01

*** P<0.001

Concentration index represented for each item by black line, 95% confidence interval represented by coloured bar.

Multivariate OLS regression analysis (table 8.1) showed that even after adjusting for all other variables, disparities in dental expenditure remained according to HRP NS-SEC; adolescents with a professional HRP generated on average, expenditure of £527.67 compared to £483.74 by adolescents with a never worked/ long-term unemployed HRP.

Multivariate analyses of expenditure on orthodontic treatment (table 8.2) revealed adolescents with a never worked/ long-term unemployed HRP had a decreased odds equal to 0.76 of having received treatment compared to adolescents with a professional HRP and generated significantly less average expenditure. £182.65 compared to £241.71. That orthodontic treatment varies according to NS-SEC supports HI in hypothesis six.

Multivariate analyses of extractions (table 8.3) revealed a social gradient whereby adolescents with a semi-routine, routine or never worked/ long-term unemployed HRP had increased odds of having received an extraction compared to adolescents with a professional HRP equal to 1.14, 1.17 and 1.34 respectively. Adolescents with a semi-routine or never worked/ long-term unemployed HRP generated significantly higher average expenditure on extractions than adolescents with a professional HRP, £6.41 and £7.39 respectively compared to £5.45. These analyses adjusted for all other factors as per other regressions but also controlled for whether or not the adolescent had received orthodontics (for reasons discussed in methods section above).

While no disparities were witnessed in relation to those who received any conservative treatment and HRP NS-SEC (table 8.4), those at the lower end of the social spectrum generated greater average expenditure; adolescents with a semi-routine, routine or never worked/ long-term unemployed HRP generated average expenditures of £56.09, £58.17 and £60.98 respectively compared to adolescents with a professional HRP who generated on average £48.48 expenditure.

This social gradient was echoed in fillings (table 8.5), which accounted for just over 85% of all conservative treatment, where adolescents with a semi-routine, routine or never worked/ long-term unemployed HRP generated higher average expenditures of

£49.27, £52.16 and £54.87 respectively compared to adolescents with a professional HRP who generated average expenditure of £44.61.

Those adolescents with a routine or never worked/ long-term unemployed HRP had an increased odds of having received endodontic treatment compared to adolescents with a professional HRP and these were equal to 1.48 and 1.44 respectively (table 8.6). Adolescents with a routine HRP generated on average higher expenditure than adolescents with a professional HRP, £4.06 compared to £1.69.

Education

No disparities were witnessed in relation to HRP education and average overall expenditure on dental services (table 8.1).

Analyses of orthodontic treatment (table 8.2) by HRP education revealed adolescents with an HRP who had no qualifications had an increased odds of having received orthodontic treatment, equal to 0.79, compared to those with an HRP who had degree and above. Adolescents with HRP education GCSEs and those with HRP education no qualifications had significantly less mean expenditure on orthodontics, £214.30 and £196.02 respectively, compared to those with HRP education degree and above, £241.71. That there exists a difference in orthodontic treatment provision in relation to HRP education supports H1 in hypothesis three.

A reverse situation existed for mean extraction consumption (table 8.3), after controlling for other variables (including orthodontic treatment) adolescents with HRP education GCSEs and those with no qualifications generated higher mean expenditure of £6.73 and £6.87 respectively, compared to those with HRP education degree and above, £5.45. Adolescents with HRP education GCSEs and those with HRP education no qualifications had increased odds of having received an extraction, of 1.26 and 1.29 respectively, compared to those with HRP education degree and above.

Within multivariate analysis, HRP education GCSEs and HRP education no qualifications generated higher expenditure on conservative treatment, £62.81 and £68.87 respectively, than HRP education degree and above, £48.48 (table 8.4).

Adolescents with a HRP education GCSEs and those with HRP education no qualifications had increased odds, equal to 1.53 and 1.76 respectively, of having received any form of conservative treatment than those with HRP education degree and above. This was also the case for fillings expenditure (table 8.5) where adolescents with HRP education GCSEs and those with HRP education no qualifications consumed on average £57.31 and £61.74 respectively, in comparison to £44.61 by adolescents with HRP education degree and above. As with conservative treatment, adolescents with HRP education GCSEs and those with HRP education no qualifications had increased odds of having received a filling, of 1.53 and 1.75 respectively compared to those with HRP education degree and above.

This pattern continued for endodontic treatment (table 8.6); adolescents with HRP education GCSEs and adolescents with HRP education no qualifications had increased odds of having received endodontics, of 1.25 and 1.42 respectively, compared to those with HRP education degree and above. Adolescents with HRP education no qualifications generated on average higher expenditure than those with HRP education degree and above, £3.52 compared to £1.69.

8.3.2.2 Gender

Females had higher overall mean dental expenditure than males, £592.64 compared to £527.67 (table 8.1). This difference was also reflected in orthodontic treatment where females generated average expenditure of £302.48 in comparison to males who generated average expenditure of £241.71 (table 8.2). Logistic regression confirmed females had increased odds, of 1.47, of having received orthodontic treatment compared to males. That orthodontic treatment varies according to gender supports HI in hypothesis eight.

After adjusting for other variables, females also consumed on average more extractions than males £6.07 compared to £5.45 (table 8.3). No gender disparities were noted in relation to conservative treatment (tables 8.4, 8.5 and 8.6).

8.3.2.3 Family structure

Within multivariate analysis, adolescents from co-habiting families generated lower mean expenditure on dental services than adolescents from married families, £493.49 compared to £527.67 (table 8.1). Adolescents from co-habiting families and adolescents from lone parent families generated on average £204.86 and £212.96 expenditure on orthodontic treatment which was lower than that of married families, who generated on average £241.71 expenditure (table 8.2). Adolescents from lone parent families also had decreased odds of 0.80 of having received orthodontics compared to those from married families. Adolescents from lone parent families were found to generate higher mean expenditure on extractions than those from married families, £6.25 compared to £5.45 (table 8.3). Those from co-habiting and those from lone parent families had increased odds of having received an extraction, equal to 1.25 and 1.17 respectively, compared to those from married families.

Upon looking at conservative treatment (table 8.4), it was found adolescents from lone parent families consumed on average more treatment than those from married families, £60.67 compared to £48.48, and also had an increased odds, equal to 1.35, of having received conservative treatment. Upon looking at sub categories, fillings and endodontics (table 8.5 and table 8.6), once again adolescents from lone parent families consumed on average more treatment, than those from married families; £52.64 compared to £44.61 for fillings and £3.92 compared to £1.69 for endodontics. Adolescents from lone parent families had increased odds of having received a filling, equal to 1.34, compared to those from married families. Adolescents from co-habiting families as well as adolescents from lone parent families had increased odds of 1.37 and 1.28 respectively, of having received endodontic treatment compared to adolescents from married families.

8.3.2.4 Family size

Within multivariate analysis, when looking at average total dental expenditure no disparities existed by family size (table 8.1). However, when looking at sub-categories of care, those from the largest families (four siblings) consumed on average significantly less orthodontic treatment (table 8.2) than those adolescents who were an only child, £193.93 compared to £241.71 and had decreased odds, equal

to 0.65, of having received orthodontic treatment. No disparities were identified in relation to family size and extractions.

Adolescents from larger families were found to consume on average more conservative treatment (table 8.4) than those who were an only child; those with two, three or four siblings consumed £58.75, £62.91 and £81.15 respectively compared to £48.48 by those who were an only child. Those with three or four siblings also had increased odds of having received conservative treatment, equal to 1.30 and 1.53 respectively, compared to an only child. The same gradient was witnessed in analysis of fillings; adolescents with two, three or four siblings had mean expenditures of £51.96, £56.66 and £60.50 respectively compared to £44.61 by adolescents who were an only child and were also more likely to have received a filling. Upon looking at endodontic treatments, disparities existed only between mean expenditure for single child families and those with three or four siblings, £1.69 compared to £3.56 and £6.88 respectively. Only those adolescents with four siblings had increased odds of having received endodontic treatment, equal to 1.68, compared to those who were an only child.

8.3.2.5 Community background

In relation to mean overall dental expenditure and expenditure on orthodontics, after adjusting for other variables, no disparities existed in relation to community background (table 8.1). However, Protestants were found to have significantly lower mean expenditure on extractions than Catholics, £4.76 compared to £5.45 (table 8.3). Protestant and other had decreased odds of having had an extraction compared to Catholics, equal to 0.91 and 0.71 respectively.

Adolescents of a community background other than Catholic or Protestant were found to consume on average less conservative treatment and less fillings than Catholics; Others generated on average £34.24 on conservative treatment compared to £48.48 for Catholics while the corresponding figures for fillings were £32.56 for other and £44.61 for Catholics (table 8.4 and table 8.5). Protestants and other had decreased odds of having received any conservative treatment than Catholics, equal

to 0.79 and 0.58 respectively. Disparities by community background were not witnessed in relation to endodontic treatment (table 8.6).

Tables 1.7 and 1.8 give summaries of the significance of disparities relating to covariates within multivariate logistic regression and multivariate OLS regression on mean expenditure.

8.4 Discussion

The main purpose of this chapter was to investigate disparities in the provision of dental healthcare. Careful examination of treatments indicated inequalities in the receipt of treatments across varying demographics/ socio-demographics after controlling for dental registration and breaks in dental registration (which were acting as proxies for dental attendance and the sporadic nature of such attendance). Inequalities may be justified if they exist due to differing needs but it may be the case inequalities exist due to differences in dental prescribing patterns which are not needs related. Further to this, it may be the case prescribed treatment is not availed of.

8.4.1 Differences in Need

Disparities were found to exist in relation to extractions carried out. The main reason for extractions is to remove tooth decay or infection, however, within this age group, extractions would also be carried out as part of orthodontic treatment. Within the extractions analyses undertaken here (figure 1.5 and table 8.3) orthodontic treatment was controlled for so that disparities in extractions for reasons other than orthodontics may be investigated. This is discussed in methods section above.

Those at the bottom of the social scale (according to HRP NS-SEC) had increased levels of extractions as well as higher average expenditure on extractions. There was also evidence to suggest lower social classes showed increased levels of earlier signs of decay as they had higher average expenditure on conservative treatment, including fillings and were more likely to have received endodontics. A previous study (160)

highlighted higher sugar consumption, one of the main causes of tooth decay, amongst lower social classes in Northern Ireland, in comparison to higher social classes. This may explain why those from lower social classes were more likely to have undergone an extraction. Also, higher social classes may place a higher value on health and therefore are likely to invest more in oral healthcare through cleaning regimes such as brushing, flossing and using mouthwash. The consequences of poor oral health such as toothache would likely cause those of higher SES greater disutility than those of lower SES e.g. through lost school days, lost time with friends or family. They are also more likely to be equipped with the resources which contribute a good oral health regime through increased income.

Disparities in extractions also existed according to education of HRP. Adolescents whose HRP had GCSEs or no qualifications were more likely to have received an extraction and had a higher mean expenditure than those adolescents whose HRP had a degree or above. Adolescents whose HRP was more highly educated were also less likely to receive conservative treatment including individual items, fillings and endodontics.

This is consistent with the predictions of Grossman's model and may be explained in that those who are more highly educated are thought to be more efficient producers of health. Here we extend this idea to that children are being influenced by parental knowledge. These results indicate the better educated are less likely to undergo extractions as a result of suffering from less tooth decay. We are perhaps seeing evidence that those HRP who are more highly educated are more likely to have a lower rate of time preference. Alongside the dentist, they act as an agent for the adolescent who will in turn have a lower rate of time preference and therefore more likely to invest in oral health. The previous chapter highlighted greater dental registration amongst adolescents with a higher educated HRP but dental registration has been controlled for here. It is likely differences in treatment received here are as a result of unobserved factors relating to diet and oral hygiene. Those who are more educated will be more knowledgeable on what constitutes good oral health and are also more likely to undertake such a regime due to a lower rate of time preference.

Disparities in extractions and conservative treatment (including fillings and endodontics) were witnessed by family structure, with adolescents from co-habiting families and adolescents from lone parent families significantly more likely to have undergone an extraction across the 2003/04-2007/08 period. Conservative treatment, including fillings and endodontic treatment was more likely amongst those with more siblings. However, no disparities were witnessed in the delivery of extractions according to siblings. Within lone parent families or those with a large number of siblings, parents are likely to have less time to allocate to each child. Hence, important oral hygiene issues may be overlooked creating a greater need for extractions amongst these groups.

Disparities witnessed in relation to extractions by community background highlighted Protestants were less likely to have received an extraction than Catholics. Catholics were also more likely to have undergone conservative treatment. It was discussed within the model in 5.4 that Catholics may have poorer lifestyle habits, indicating a higher discount rate (higher time preference) and therefore are less likely to invest in oral health. Although dental registration has been controlled for within the analyses, lifestyle habits such as diet, smoking and drinking have not. These results would seem to indicate a higher need for extractions amongst Catholics as a result of these other lifestyle factors. It should also be noted community background may also be picking up some aspects of income which NS-SEC has missed as we know there exists a relationship between deprivation and community background within Northern Ireland (161).

This study has revealed differences in the receipt of orthodontic treatment according to measures of SES (NS-SEC and education of HRP), gender, family structure and family size. Orthodontic need is not thought to be related to any of these socio-demographics; equal need for orthodontic treatment has been previously identified across gender and SES (79). Instead, variations in treatment delivery are thought to exist as a result of differences in treatment uptake or as a result of differences in dentist prescribing patterns.

8.4.2 Differences in treatment uptake

First consider differences in treatment uptake. The economic model in 5.4 proposed that dentists act as perfect agents and that orthodontic treatment uptake may be higher amongst higher income groups (as measured here by HRP NS-SEC). The model suggested higher income groups may be more likely to undertake orthodontic treatment due to the higher utility they are likely to derive from greater social acceptance and job opportunities associated with increased aesthetic appearance. This may therefore explain why after adjusting for all other factors, those perceived to be on the lowest incomes were less likely to have received and had lower average expenditure on orthodontics than those perceived to be on the highest incomes.

This study also revealed provision of orthodontics was significantly less likely and average expenditure was lower amongst adolescents with the lowest qualified HRPs compared to those with the highest qualified HRPs. Again, treating dentists as perfect agents, as within the economic model presented, those with the highest qualifications will likely have a lower rate of time preference and hence a lower discount rate. Therefore, they are more likely to invest now in order to receive future benefits. Although it is the education of the HRP, and therefore most likely the parent of the adolescent, being observed, the HRP is effectively investing in the adolescents future oral health as both parties are likely to derive utility from this investment. Undergoing orthodontic treatment can be seen as an investment; although in the short-term the treatment may appear unattractive, and requires time and cost to travel to appointments, the future benefits to be gained are aesthetically appealing.

Females were found to be in greater receipt of orthodontics than males. Explaining this in the context of the economic model where the dentist is a perfect agent, implies greater uptake of orthodontics amongst females rather than dentists discriminating against males in their prescribing patterns. Females are likely to derive more utility from good oral health than males due to differences in perceived pressures in society on males and females regarding physical appearance. Orthodontic treatment will help improve aesthetic appearance.

Inequalities in orthodontic treatment also existed with regards family structure; in comparison to adolescents from married families, those from lone parent families were less likely to receive orthodontic treatment. Also, those from the largest families (4 siblings) were less likely to receive orthodontic treatment. Lone parents or parents of many children may be less likely to undertake orthodontic treatment due to a restriction on their time, money and the organisation skills required for single parenting or many children. Orthodontic treatment can require several treatment visits and often this will be to a specialised orthodontist which may be more costly both in terms of time and money than regular dental visiting.

8.4.3 Differences in dental prescribing patterns

However, differences witnessed with respect to orthodontic treatment provision may also be related to dentist prescribing patterns. Assuming dentists act as perfect agents on the adolescents' behalf, dentists may believe certain groups, for example those on higher incomes or those more highly educated will derive greater utility from orthodontic treatment as they are less likely to suffer from tooth decay requiring extractions. Orthodontic treatments have been shown to increase the risk of developing caries (162, 163). Therefore, once again assuming dentists act as perfect agents, it may be that dentists do not wish to expose those already with an increased risk to developing caries to further risk. However, dentists may be offering preferential treatment to those farthest up the social hierarchy. Perhaps dentists perceive an opportunity in providing highly satisfactory services such as orthodontics to higher income families; wealthy parents may be more likely to use this dentist and perhaps demand expensive aesthetic dental treatment[30] therefore allowing the dentist to maximise profit. This study cannot prove or disprove this theory but merely suggests this may be the case.

Differences in dental prescribing patterns may be due to those who are more highly educated being more knowledgeable on the treatments available to them and hence being able to exert greater influence on the treatments they receive. It may also be that those who are more highly educated are better able to articulate their needs.

[30] Such treatments include teeth whitening, veneers, crowns, white fillings, orthodontics, gum reshaping and dental bridges.

Influencing of treatment and conveying of treatment needs may be carried out by a parent on behalf of the adolescent.

8.5 Conclusion

Analysis of total dental healthcare expenditure revealed intensity of dental services usage is lower amongst those at the bottom of the social scale (according to HRP NS-SEC). However, analysis of individual treatments revealed costs are driven by orthodontic treatment; higher social classes have higher average expenditure on orthodontic treatment but lower average expenditure on extractions and conservative treatment. This pattern of treatment delivery is concerning as it may serve to widen social disparities in oral health.

Patterns of orthodontic treatment witnessed, favouring higher social classes, females, those from married families and those who are an only child compared to those with four siblings, are unlikely to be attributed to differences in need. Instead, inequities in dental prescribing patterns or differences in treatment uptake are likely explanations. If the former of these explanations is to blame, once again, as discovered with dental registration, the NHS is not providing equal access for equal need.

The characteristics of those who are more likely to be administered extractions or undergo conservative treatment are similar; lower social class, those from co-habiting or lone parent families and Catholics. This would suggest need for protection from dental decay is higher amongst these groups.

Although this study did not contain an analysis of treatments provided by the community dental service and the hospital dental service, it would be unlikely the relationships witnessed here would be any less significant was such information made available. The hospital dental service often carries out more complex oral surgery and multiple extractions as these can be done under general anaesthetic within a hospital. As lower social classes have higher levels of extractions within the general dental service and higher levels of restorative work, they are more likely to

have multiple extractions within a hospital. Therefore, the inclusion of treatments carried out within the hospital dental service is likely to make the relationship between SES and extractions even more significant. The work carried out by the community dental service can only be speculated on here but it seems likely that if the nature of contact is mainly sporadic which does not require registration, then restorative work is more likely to be carried out as many adolescents with attend only when experiencing dental problems. As we know one purpose of the community dental service is to serve those of low social class therefore it may seem reasonable to assume that including community dental service treatments would increase the significance of the relationship between restorative work and SES.

The next chapter will discuss how policy and the way in which dental health services are administered may be amended to deal with the issues chapters 7 and 8 have uncovered in relation to dental registration and dental treatments.

Table 8.1 OLS multivariate regression for expenditure on GDP services 2003/04 - 2007/08, 12,846 adolescents in NILS (registration and breaks in registration also controlled for)

		Multivariate[1] OLS regression on mean expenditure		
Independent variable	No.	Mean cost	Difference in means	P value[2]
HRP NS-SEC				0.1431
Professional	3,826	527.67 (489.69, 565.65)	0.00	
Intermediate	1,027	521.94 (493.98, 549.91)	-5.73 (-33.69, 22.24)	0.688
Self-employed	2,069	518.26 (494.90, 541.61)	-9.41 (-32.77, 13.94)	0.430
Semi-routine	3,048	522.14 (501.01, 543.25)	-5.53 (-26.66, 15.58)	0.607
Routine	2,079	526.73 (502.93, 550.54)	-0.94 (-24.74, 22.87)	0.939
Never worked/ long-term unemployed	797	**483.74 (455.12, 512.34)**	**-43.93 (-72.55, -15.33)**	**0.003**
HRP education				0.2407
Degree and above	2,241	527.67 (489.69, 565.65)	0.00	
Two or more a-levels	769	514.90 (483.12, 546.67)	-12.46 (-45.85, 20.93)	0.465
GCSEs	4,859	519.44 (498.02, 514.27)	-8.12 (-30.86, 14.62)	0.484
No qualifications	4,977	505.66 (482.23, 529.10)	-21.72 (-46.21, 2.77)	0.082
Gender				**0.0000**
Male	6,584	527.67 (489.69, 565.65)	0.00	
Female	6,262	**592.64 (579.46, 605.82)**	**65.05 (51.83, 78.26)**	**0.000**
Family structure				0.1013
Married	6,602	527.67 (489.69, 565.65)	0.00	
Co-habiting	414	**493.49 (459.57, 527.40)**	**-34.18 (-68.10, -0.27)**	**0.048**
Lone parent	2,830	514.65 (497.58, 531.72)	-13.02 (-30.09, 4.05)	0.135
Siblings				0.7314
0	1,041	527.67 (489.69, 565.65)	0.00	
1	4,365	529.19 (503.48, 554.91)	1.52 (-24.19, 27.24)	0.907

2	4,298	534.08 (508.26, 559.91)	6.41 (-19.41, 32.24)	0.626
3	2,880	522.35 (495.33, 549.37)	-5.32 (-32.34, 21.70)	0.700
4	262	513.78 (470.53, 557.02)	-13.89 (-57.14, 29.35)	0.529
Community background				0.2112
Catholic	6,372	527.67 (489.69, 565.65)	0.00	
Protestant	5,917	518.80 (504.86, 532.74)	-8.87 (-22.81, 5.07)	0.212
Other	557	502.51 (469.47, 535.55)	-25.16 (-58.20, 7.88)	0.136

[1] Reports on robust standard errors

[2] Categorical P-values based on likelihood-ratio test

Table 8.2 Logistic and OLS multivariate regressions for expenditure on orthodontic treatment 2003/04 - 2007/08, 12,846 adolescents in NILS (registration and breaks in registration controlled for)

		Multivariate logistic regression		Multivariate[1] OLS regression on mean expenditure		
Independent variable	No.	Odds ratio	P value[2]	Mean cost	Difference in means	P value[2]
HRP NS-SEC			0.1425			**0.0138**
Professional	3,826	1.00		241.71 (205.65,277.78)	0.00	
Intermediate	1,027	1.03 (0.89, 1.21)	0.643	232.31 (205.90, 258.72)	-9.40 (-35.81, 17.01)	0.485
Self-employed	2,069	1.02 (0.89, 1.16)	0.808	226.96 (204.88, 249.05)	-14.75 (-36.83, 7.34)	0.191
Semi-routine	3,048	1.00 (0.89, 1.13)	0.977	226.09 (206.13, 246.06)	-15.62 (-35.58, 4.35)	0.125
Routine	2,079	0.96 (0.84, 1.11)	0.605	228.47 (205.97,250.96)	-13.24 (-35.74, 9.25)	0.248
Never worked/ long-term unemployed	797	**0.76 (0.62, 0.95)**	**0.013**	**182.65 (156.20, 209.10)**	**-59.06 (-85.51, -32.61)**	**0.000**
HRP education			**0.0022**			**0.0006**
Degree and above	2,241	1.00		241.71 (205.65, 277.78)	0.00	
Two or more a-levels	769	1.00 (0.83, 1.19)	0.965	225.34 (193.58, 257.10)	-16.37 (-48.13, 15.39)	0.312
GCSEs	4,859	0.91 (0.80, 1.02)	0.104	**214.30 (192.60, 236.01)**	**-27.41 (-49.11, -5.70)**	**0.013**
No qualifications	4,977	**0.79 (0.69, 0.91)**	**0.001**	**196.02 (172.64, 219.41)**	**-45.69 (-69.07, -22.30)**	**0.000**
Gender			**0.0000**			**0.0000**
Male	6,584	1.00		241.71 (205.65, 277.78)		
Female	6,262	**1.47 (1.36, 1.59)**	**0.000**	**302.48 (290.04, 314.92)**	**60.77 (48.33, 73.21)**	**0.000**
Family structure			**0.0001**			**0.0000**
Married	9,602	1.00		241.71 (205.65, 277.78)		
Co-habiting	414	0.81 (0.64, 1.02)	0.071	**204.86 (172.98, 236.74)**	**-36.85 (-68.73, -4.97)**	**0.024**
Lone parent	2,830	**0.80 (0.72, 0.89)**	**0.000**	**212.96 (197.05, 228.86)**	**-28.75 (-44.66, -12.85)**	**0.000**
Siblings			**0.0239**			**0.0631**
0	1,041	1.00		241.71 (205.65, 277.78)	0.00	
1	4,365	1.01 (0.87, 1.18)	0.890	242.88 (218.40, 267.37)	1.17 (-23.31, 25.66)	0.925
2	4,298	0.98 (0.84, 1.15)	0.841	239.01 (214.37, 263.66)	-2.70 (-27.34, 21.95)	0.830
3	2,880	0.89	0.153	223.20	-18.51	0.158

		(0.75, 1.05)		(197.49, 248.90)	(-44.22, 7.19)	
4	262	**0.65 (0.45, 0.95)**	**0.026**	**193.93 (156.24, 231.61)**	**-47.78 (-85.47, -10.10)**	**0.013**
Community background			0.7657			0.8975
Catholic	6,372	1.00		241.71 (205.65, 277.78)	0.00	
Protestant	5,917	1.03 (0.95, 1.12)	0.467	239.02 (225.90, 252.14)	-2.69 (-15.81, 10.43)	0.687
Other	557	1.03 (0.77, 1.37)	0.856	236.73 (205.40, 268.06)	-4.98 (-36.31, 26.35)	0.755

[1] Reports on robust standard errors

[2] Categorical P-values based on likelihood-ratio test

Table 8.3 Logistic and OLS multivariate regressions for expenditure on extractions 2003/04 - 2007/08, 12,846 adolescents in NILS (registration and breaks in registration controlled for)

		Multivariate logistic regression[3]		Multivariate[1,3] OLS regression on mean expenditure		
Independent variable	No.	Odds ratio	P value[2]	Mean cost	Difference in means	P value[2]
HRP NS-SEC			**0.0433**			**0.0673**
Professional	3,826	1.00		5.45 (3.87, 7.04)	0.00	
Intermediate	1,027	1.16 (0.99, 1.36)	0.065	6.42 (5.27, 7.56)	0.97 (-0.18, 2.11)	0.099
Self-employed	2,069	1.14 (1.00, 1.30)	0.053	5.90 (4.99, 6.82)	0.45 (-0.46, 1.37)	0.332
Semi-routine	3,048	**1.14 (1.01, 1.28)**	**0.035**	**6.41 (5.53, 7.28)**	**0.96 (0.08, 1.83)**	**0.032**
Routine	2,079	**1.17 (1.02, 1.34)**	**0.025**	5.99 (5.02, 6.97)	0.54 (-0.43, 1.52)	0.277
Never worked/ long-term unemployed	797	**1.34 (1.11, 1.62)**	**0.002**	**7.39 (5.97, 8.81)**	**1.94 (0.52, 3.36)**	**0.007**
HRP education			**0.0017**			**0.0224**
Degree and above	2,241	1.00		5.45 (3.87, 7.04)	0.00	
Two or more a-levels	769	1.20 (0.99, 1.44)	0.057	6.08 (4.76, 7.40)	0.63 (-0.69, 1.95)	0.349
GCSEs	4,859	**1.26 (1.11, 1.43)**	**0.000**	**6.73 (5.86, 7.61)**	**1.28 (0.41, 2.16)**	**0.004**
No qualifications	4,977	**1.29 (1.12, 1.48)**	**0.000**	**6.87 (5.90, 7.84)**	**1.42 (0.45, 2.39)**	**0.004**
Gender			0.1514			**0.0270**
Male	6,584	1.00		5.45 (3.87, 7.04)	0.00	
Female	6,262	1.06 (0.98, 1.14)	0.151	**6.07 (5.51, 6.62)**	**0.62 (0.06, 1.17)**	**0.029**
Family structure			**0.0028**			**0.0249**
Married	9,602	1.00		5.45 (3.87, 7.04)	0.00	
Co-habiting	414	**1.25 (1.01, 1.55)**	**0.042**	7.04 (5.38, 8.69)	1.59 (-0.07, 3.24)	0.060
Lone parent	2,830	**1.17 (1.06, 1.30)**	**0.002**	**6.25 (5.49, 7.01)**	**0.80 (0.04, 1.56)**	**0.039**
Siblings			0.1985			0.9098
0	1,041	1.00		5.45 (3.87, 7.04)	0.00	
1	4,365	0.92 (0.79, 1.07)	0.262	5.05 (3.92, 6.18)	-0.40 (-1.53, 0.73)	0.488
2	4,298	0.96 (0.83, 1.12)	0.638	5.06 (3.92, 6.20)	-0.39 (-1.53, 0.75)	0.499
3	2,880	0.93	0.369	5.15	-0.30	0.630

		(0.79, 1.09)		(3.93, 6.37)	(-1.52, 0.92)	
4	262	1.25 (0.93, 1.68)	0.136	5.78 (3.69, 7.87)	0.33 (-1.76, 2.42)	0.757
Community background			**0.0089**			**0.0553**
Catholic	6,372	1.00		5.45 (3.87, 7.04)	0.00	
Protestant	5,917	**0.91** **(0.84, 0.99)**	**0.020**	**4.76** **(4.17, 5.35)**	**-0.69** **(-1.28, -0.10)**	**0.022**
Other	557	**0.71** **(0.53, 0.95)**	**0.021**	4.70 (3.29, 6.12)	-0.75 (-2.16, 0.67)	0.301

[1] Reports on robust standard errors

[2] Categorical P-values based on likelihood-ratio test

[3] Controlling for orthodontics

Table 8.4 Logistic and OLS multivariate regressions for expenditure on conservative treatment 2003/04 - 2007/08, 12,846 adolescents in NILS (registration and breaks in registration controlled for)

		Multivariate logistic regression		Multivariate[1] OLS regression on mean expenditure		
Independent Variable	No.	Odds ratio	P value[2]	Mean cost	Difference in means	P value[2]
HRP NS-SEC			0.5666			**0.0044**
Professional	3,826	1.00		48.48 (39.89, 57.07)	0.00	
Intermediate	1,027	1.01 (0.84, 1.20)	0.948	50.59 (43.69, 57.51)	2.11 (-4.79, 9.03)	0.547
Self-employed	2,069	1.05 (0.91, 1.23)	0.495	51.51 (46.17, 56.85)	3.03 (-2.31, 8.37)	0.266
Semi-routine	3,048	1.12 (0.98, 1.29)	0.095	**56.09 (51.16, 61.01)**	**7.61 (2.68, 12.53)**	**0.002**
Routine	2,079	1.12 (0.96, 1.32)	0.161	**58.17 (52.47, 63.87)**	**9.69 (3.99, 15.39)**	**0.001**
Never worked/ long-term unemployed	797	1.13 (0.90, 1.42)	0.296	**60.98 (52.14, 69.83)**	**12.50 (3.66, 21.35)**	**0.006**
HRP education			**0.0000**			**0.0000**
Degree and above	2,241	1.00		48.48 (39.89, 57.07)	0.00	
Two or more a-levels	769	1.13 (0.93, 1.38)	0.219	50.83 (44.28, 57.39)	2.35 (-4.20, 8.91)	0.481
GCSEs	4,859	**1.53 (1.34, 1.76)**	**0.000**	**62.81 (58.15, 67.47)**	**14.33 (9.67, 18.99)**	**0.000**
No qualifications	4,977	**1.76 (1.52, 2.05)**	**0.000**	**68.87 (63.63, 74.11)**	**20.39 (15.15, 25.63)**	**0.000**
Gender			0.4563			0.1728
Male	6,584	1.00		48.48 (39.89, 57.07)	0.00	
Female	6,262	0.97 (0.89, 1.06)	0.456	46.21 (42.95, 49.47)	-2.27 (-5.53, 0.99)	0.172
Family structure			**0.0000**			**0.0000**
Married	9,602	1.00		48.48 (39.89, 57.07)	0.00	
Co-habiting	414	1.07 (0.84, 1.38)	0.582	50.11 (42.24, 57.97)	1.63 (-6.24, 9.49)	0.685
Lone parent	2,830	**1.35 (1.19, 1.53)**	**0.000**	**60.67 (55.91, 65.44)**	**12.19 (7.43, 16.96)**	**0.000**
Siblings			**0.0004**			**0.0000**
0	1,041	1.00		48.48 (39.89, 57.07)	0.00	
1	4,365	1.07 (0.90, 1.27)	0.482	50.85 (44.75, 40.00)	2.37 (-3.73, 8.48)	0.446
2	4,298	1.27 (1.07, 1.51)	0.006	**58.75 (52.56, 64.93)**	**10.27 (4.08, 16.45)**	**0.001**
3	2,880	**1.30**	**0.004**	**62.91**	**14.43**	**0.000**

		(1.09, 1.57)		**(56.27, 69.56)**	**(7.79, 21.08)**	
4	262	**1.53 (1.04, 2.26)**	**0.031**	**81.15 (62.17, 100.14)**	**32.67 (13.69, 51.66)**	**0.001**
Community background			**0.0000**			**0.0000**
Catholic	6,372	1.00		48.48 (39.89, 57.07)	0.00	
Protestant	5,917	**0.79 (0.72, 0.87)**	**0.000**	46.28 (42.75, 49.81)	-2.20 (-5.73, 1.33)	0.221
Other	557	**0.58 (0.43, 0.78)**	**0.000**	**34.24 (27.52, 40.96)**	**-14.24 (-20.96, -7.52)**	**0.000**

[1] Reports on robust standard errors

[2] Categorical P-values based on likelihood-ratio test

Table 8.5 Logistic and OLS multivariate regressions for expenditure on fillings 2003/04 - 2007/08, 12,846 adolescents in NILS (registration and breaks in registration controlled for)

		Multivariate logistic regression		Multivariate[1] OLS regression on mean expenditure		
Independent Variable	No.	Odds ratio	P value[2]	Mean cost	Difference in means	P value[2]
HRP NS-SEC			0.5462			**0.0015**
Professional	3,826	1.00		44.61 (37.88, 51.34)	0.00	
Intermediate	1,027	**1.01 (0.85, 1.21)**	0.889	44.86 (39.86, 49.87)	0.25 (-4.75, 5.26)	0.921
Self-employed	2,069	1.06 (0.91, 1.24)	0.424	47.01 (43.87, 51.14)	2.40 (-1.74, 6.53)	0.256
Semi-routine	3,048	1.12 (0.98, 1.29)	0.096	**49.27 (45.62, 52.91)**	**4.66 (1.01, 8.30)**	**0.012**
Routine	2,079	1.14 (0.97, 1.34)	0.112	**52.16 (47.88, 56.45)**	**7.55 (3.27, 11.84)**	**0.001**
Never worked/ long-term unemployed	797	1.12 (0.89, 1.40)	0.337	**54.87 (48.66, 61.08)**	**10.26 (4.05, 16.47)**	**0.001**
HRP education			**0.0000**			**0.0000**
Degree and above	2,241	1.00		44.61 (37.88, 51.34)	0.00	
Two or more a-levels	769	1.11 (0.91, 1.35)	0.304	4.63 (42.28, 52.97)	3.02 (-2.33, 8.36)	0.268
GCSEs	4,859	**1.53 (1.33, 1.75)**	**0.000**	**57.31 (53.71, 60.92)**	**12.70 (9.10, 16.31)**	**0.000**
No qualifications	4,977	**1.75 (1.50, 2.03)**	**0.000**	**61.74 (57.73, 65.75)**	**17.13 (13.12, 21.14)**	**0.000**
Gender			0.4439			0.3423
Male	6,584	1.00		44.61 (37.88, 51.34)	0.00	
Female	6,262	0.97 (0.89, 1.05)	0.444	43.45 (41.05, 45.85)	-1.16 (-3.56, 1.24)	0.343
Family structure			**0.0000**			**0.0005**
Married	9,602	1.00		44.61 (37.88, 51.34)	0.00	
Co-habiting	414	1.08 (0.84, 1.38)	0.564	48.47 (41.92, 55.02)	3.86 (-2.69, 10.41)	0.248
Lone parent	2,830	**1.34 (1.18, 1.52)**	**0.000**	**52.64 (49.36, 55.92)**	**8.03 (4.75, 11.31)**	**0.000**
Siblings			**0.0004**			**0.0000**
0	1,041	1.00		44.61 (37.88, 51.34)	0.00	
1	4,365	1.06 (0.89, 1.25)	0.505	46.12 (41.48, 50.76)	1.51 (-3.13, 6.15)	0.525
2	4,298	**1.27 (1.07, 1.51)**	**0.007**	**51.96 (47.27, 56.66)**	**7.35 (2.66, 12.05)**	**0.002**

3	2,880	**1.30 (1.08, 1.56)**	**0.005**	**56.66 (51.56, 61.77)**	**12.05 (6.95, 17.16)**	**0.000**
4	262	**1.48 (1.01, 2.17)**	**0.045**	**60.50 (50.38, 70.62)**	**15.89 (5.77, 26.01)**	**0.002**
Community background			**0.0000**			**0.0000**
Catholic	6,372	1.00		44.61 (37.88, 51.34)	0.00	
Protestant	5,917	**0.79 (0.72, 0.87)**	**0.000**	43.35 (40.80, 45.91)	-1.26 (-3.81, 1.30)	0.336
Other	557	0.56 (0.42, 0.75)	0.000	**32.56 (27.29, 37.83)**	**-12.05 (-17.32, -6.78)**	**0.000**

[1] Reports on robust standard errors

[2] Categorical P-values based on likelihood-ratio test

Table 8.6 Logistic and OLS multivariate regressions for expenditure on endodontics 2003/04 - 2007/08, 12,846 adolescents in NILS (registration and breaks in registration controlled for)

		Multivariate Logistic regression		Multivariate[1] OLS regression on mean expenditure		
Independent Variable	No.	Odds ratio	P value[2]	Mean cost	Difference in means	P value[2]
HRP NS-SEC			**0.0055**			**0.0661**
Professional	3,826	1.00		1.69 (-0.51, 3.88)	0.00	
Intermediate	1,027	1.23 (0.95, 1.58)	0.114	3.12 (1.34, 4.91)	1.43 (-0.35, 3.22)	0.114
Self-employed	2,069	1.13 (0.92, 1.40)	0.250	2.28 (0.92, 3.63)	0.59 (-0.77, 1.94)	0.398
Semi-routine	3,048	1.16 (0.96, 1.42)	0.125	2.48 (1.23, 3.73)	0.79 (-0.46, 2.04)	0.214
Routine	2,079	**1.48 (1.20, 1.82)**	**0.000**	**4.06 (2.49, 5.63)**	**2.37 (0.80, 3.94)**	**0.003**
Never worked/ long-term unemployed	797	**1.44 (1.10, 1.88)**	**0.009**	2.78 (0.60, 4.95)	1.09 (-1.09, 3.26)	0.328
HRP education			**0.0131**			**0.0431**
Degree and above	2,241	1.00		1.69 (-0.51, 3.88)	0.00	
Two or more a-levels	769	1.06 (0.77, 1.47)	0.712	1.25 (-0.36, 2.86)	-0.44 (-2.05, 1.17)	0.594
GCSEs	4,859	**1.25 (1.01, 1.56)**	**0.042**	2.63 (1.41, 3.84)	0.94 (-0.28, 2.15)	0.133
No qualifications	4,977	**1.42 (1.13, 1.79)**	**0.003**	**3.52 (2.14, 4.90)**	**1.83 (0.45, 3.21)**	**0.009**
Gender			0.1782			0.7561
Male	6,584	1.00		1.69 (-0.51, 3.88)	0.00	
Female	6,262	0.92 (0.82, 1.04)	0.178	1.55 (0.69, 2.41)	-0.14 (-1.00, 0.72)	0.755
Family structure			**0.0018**			0.3962
Married	9,602	1.00		1.69 (-0.51, 3.88)	0.00	
Co-habiting	414	**1.37 (1.01, 1.87)**	**0.042**	1.62 (-0.38, 3.62)	-0.07 (-2.07, 1.93)	0.942
Lone parent	2,830	**1.28 (1.10, 1.49)**	**0.001**	**3.92 (2.57, 5.26)**	**2.23 (0.88, 3.57)**	**0.001**
Siblings			**0.0002**			**0.0008**
0	1,041	1.00		1.69 (-0.51, 3.88)	0.00	
1	4,365	0.93 (0.74, 1.18)	0.568	1.75 (0.17, 3.32)	0.06 (-1.52, 1.63)	0.944
2	4,298	1.22 (0.96, 1.54)	0.099	3.12 (1.50, 4.74)	1.43 (-0.19, 3.05)	0.084
3	2,880	1.23	0.102	**3.56**	**1.87**	**0.036**

		(0.96, 1.57)		**(1.81, 5.32)**	**(0.12, 3.63)**	
4	262	**1.68 (1.14, 2.48)**	**0.009**	**6.88 (2.20, 11.56)**	**5.19 (0.51, 9.87)**	**0.030**
Community background			0.0719			**0.0008**
Catholic	6,372	1.00		1.69 (-0.51, 3.88)	0.00	
Protestant	5,917	0.90 (0.80, 1.02)	0.096	1.08 (0.16, 2.00)	-0.61 (-1.53, 0.31)	0.192
Other	557	0.63 (0.37, 1.08)	0.095	0.98 (-1.11, 3.08)	-0.71 (-2.80, 1.39)	0.508

[1] Reports on robust standard errors
[2] Categorical P-values based on likelihood-ratio test

Table 8.7: Likelihood ratio tests relating to multivariate logistic regression of GDP services usage 2003/04 - 2007/08

	HRP NS-SEC P value	HRP education P value	Gender P value	Family structure P value	Siblings P value	Community background P value
Orthodontics	-	***	****	****	**	-
Extractions	**	***	-	***	-	***
Conservative	-	****	-	****	****	****
Fillings	-	****	-	****	****	****
Endodontics	***	**	-	***	****	*

**** Statistically significant at 99.9% (p<0.001)
*** Statistically significant at 99% (p<0.01)
** Statistically significant at 95% (p<0.05)
* Statistically significant at 90% (p<0.10)

Table 8.8: Likelihood ratio tests relating to multivariate OLS regression on mean expenditure of GDP services 2003/04 - 2007/08

	HRP NS-SEC P value	HRP education P value	Gender P value	Family structure P value	Siblings P value	Community background P value
Total Expenditure	-	-	****	-	-	-
Orthodontics	**	****	****	****	*	-
Extractions	*	**	**	**	-	*
Conservative	***	****	-	****	****	***
Fillings	***	****	-	****	****	****
Endodontics	*	**	-	-	****	****

**** Statistically significant at 99.9% (p<0.001)
*** Statistically significant at 99% (p<0.01)
** Statistically significant at 95% (p<0.05)
* Statistically significant at 90% (p<0.10)

9 Discussion and conclusions

9.1 Main findings

This thesis has examined social inequalities in both oral health and in the registration for and use of dental services amongst adolescents. A systematic review undertaken (chapter 2) identified those from lower social classes were more likely to have poorer oral health. An exploration of self-reported oral health within a Californian adolescent population (chapter 3) revealed socio-economic differentials in oral health were almost fully explained by health influencing behaviours (relating to BMI and physical activity), dental care and the social environment (e.g. language barriers). As the rest of this thesis was undertaken on data available for the UK, it would have been ideal to investigate socio-economic differentials in oral health within the UK. However, such a dataset containing a measure of and factors thought to influence oral health is currently not available within the UK (although the national Children's Dental Health and Adult's dental Health surveys give information on oral health, factors thought to influence oral health are not available). Therefore, although these results will have some applicability to the UK (both are developed countries with partial fluoridation) some differences between California and the UK would be in the provision of dental healthcare and the racial/ ethnic mix. However, affordability of dental healthcare in California was not found to be an underlying factor of oral health inequalities and this would also be the case in the UK were the NHS provides dental care to all adolescents free of charge. This study has important findings, socio-economic differentials in oral health may be amenable to change.

After identifying a SES gradient in oral health, chapters 7 and 8 sought to identify the relationship between SES and the registration for and use of dental treatments amongst adolescents in the NHS General Dental Service within Northern Ireland. Inequalities both in registration and use were found to exist across socio-demographics (relating to occupation and highest educational attainment of HRP), family structure and family size, community background and gender. Registration for dental services was also found to vary according to adolescent age.

Regarding social inequalities in relation to registration (chapter 7), disparities were witnessed in relation to occupation of HRP and highest educational attainment of HRP; occupations further down the NS-SEC scale and those with lower educational attainment exhibited lower dental registration. The systematic review (Chapter 2) identified that those from lower social backgrounds have poorer oral health and hence an increased need for care. Therefore, it would appear those who need dental care most are least likely to have access to dental services. While it is likely lower levels of access to dental services (and hence lower levels of preventive dentistry and less opportunity for dentists to treat early) increase the need for dental care amongst lower social classes it is not just access to care that underlies SES differentials. The research carried out in Chapter 3 found SES differentials in oral health are also explained by health influencing behaviours and language barriers (but these are less likely to be a factor in Northern Ireland as it is much less diverse than California). Further, as 'The NHS is founded on the principles of access being equal for all, and services being free at the point of use and based on clinical need, not the ability to pay,' (18) it would appear the NHS is not achieving this principle.

Disparities in relation to registration for dental services were also witnessed according to a number of demographics. Those adolescents from unmarried families (compared to married) and those with four siblings (compared to none) demonstrated lower levels of registration. Catholics had lower levels of registration than Protestants. When adolescents were older (15-17 years old), a gender disparity was witnessed whereby females had higher registration than males. No gender disparity existed when adolescents were younger (11-13 years old). Overall, dental registration was significantly lower for older adolescents than for younger adolescents.

Upon looking at total dental expenditure, it was discovered the highest expenditure was on orthodontic treatments, followed by registration fees. Significant differences were witnessed in relation to delivery of dental treatments and these remained after controlling for dental registration. Patterns of dental care differed according to occupation of HRP, lower social classes were more likely to have received an extraction and conservative treatment (fillings, endodontics etc) while less likely to have received orthodontics. A similar pattern was witnessed in relation to education of HRP; low education was linked to lower receipt of orthodontics but higher receipt

of conservative treatment and extractions. This system of extracting or conserving the teeth of those with lower SES whilst aesthetically improving the teeth of those with higher SES may be widening existing social disparities in oral health.

Patterns in treatment delivery witnessed in relation to SES were also witnessed according to family structure and community background, favouring adolescents from married families and Protestants.

This study also identified disparities in orthodontic treatment. It tended to be those groups more likely to have received extractions and conservative work, were less likely to have received orthodontics. This current system may be widening oral health disparities. Within this study 45% of total dental expenditure was on orthodontics (£2, 749 258). While adolescents in the highest social class (according to HRP NS-SEC) accounted for 30% of the sample population, they accounted for 36% of the orthodontic expenditure.

9.2 Policy implications

In order to ameliorate inequalities in dental registration, policy needs to identify ways of making dental care more accessible to adolescents who display such characteristics (as discussed above). During this study, in 2006/07, the SDR was amended to provide incentives for dentists to accept more children (aged 6-17 years) from deprived areas whereby capitation fees were increased for such individuals by 50%[31]. Although we do not directly test the outcome of this amendment, the effect on dental registration at an individual level was limited as HRP NS-SEC inequalities which existed in 2003/04 remained in 2007/08. Although amendments such as these are a move in the right direction with regard to addressing inequalities in dental registration, given the contribution of capitation to overall income, they may have limited capabilities of significantly changing behaviour.

[31] The SDR states that a 50% additional fee to the basic registration fee is payable where a patient aged between 6 and 17 years has a postcode address within a Northern Ireland electoral ward with a DMFT score of 2.96 or above.

The answer to eliminating inequalities in dental registration might lie in providing dental treatment to all adolescents in the school environment, whether this is feasible given its impact on school teaching commitments is debatable. Dental screening carried out by the Community Dental Service on primary school children ceased in 2007/08 as recent research (164) undertaken by the University of Manchester concluded only a small proportion of children identified as in need of treatment actually went on to receive treatment. This therefore shows the importance of providing treatment as well as screening within schools. Such a system is currently delivered within the Republic of Ireland (165) which boasts lower social disparities in oral health (even when comparing non-fluoridated populations in Republic of Ireland to Northern Ireland)[32] (166).

Providing dental screening and treatments within schools may help to reduce disparities in access to dental care however, this study also highlighted disparities in treatment provision across SES and a number of demographics after controlling for a measure of dental attendance (which is likely to reflect opportunity for dentists to prevent and treat teeth).

A demand-led service in which practitioners are reimbursed in part on a fee for service basis may be creating incentives that contribute to patterns of utilization that favour the more affluent. Creating a pattern of utilization that relects users' desires rather than needs and which, within a financially constrained publicly funded system may serve to distort society's priorities. Therefore, in order to tackle inequalities in the provision of dental treatments, the answer may lie in moving away from a fee for service arrangement. Proposals for a new contract in England and Wales will focus on prevention and quality rather than treatment (167). A new dental contract is due to be rolled out in Northern Ireland in 2013.

One way of tackling inequalities in the provision of dental treatments may be to encourage dentists to play more of an active role in their patients' oral health. If however, a framework was introduced which rewards dentists for how well they care

[32] This report highlighted mean DMFT scores in 15 year olds were 3.9 and 3.8 for disadvantaged and non-disadvantaged respectively in the Republic of Ireland compared to 5.3 and 3.8 in Northern Ireland.

for patients rather than how much treatment they provide, they may be more likely to take the time to provide preventive advice and may spend more time cleaning teeth, removing plaque and providing topical fluoride or fissure sealants. This system would be similar to the Quality and Outcomes Framework which currently financially rewards General Practitioners for the prevention of certain chronic conditions (168). Such a system may also help to deal with the disparities in dental registration which were found to exist. In an effort to care more for patients' health, dentists may make more effort to retain patients and encourage check-ups. As a result, dentists are provided greater opportunity to care for patients' teeth than would be the case if check-ups did not take place and registration lapsed. A target for provision of orthodontics could also be included within the framework. This would ensure dentists are making efforts to deliver orthodontics to all those in need and that preferential treatment is not being offered to particular groups e.g. more affluent members of society.

Clearly, in order for such a system to work successfully bonuses would have to be larger than the profit dentists would accrue for delivering treatments. Alternatively, the way in which dentists are reimbursed could be re-structured to resemble that of GPs whereas to a standard salary is paid and bonuses allocated for targets met.

However, in administering such a system, dentists would need access to a greater range of preventive treatments. Chapter 3 showed oral health needs of the population differ according to SES, therefore, some groups would benefit more from preventive dentistry than others. Within the SDR, topical fluoride is one of only a few preventive treatments, yet this is not made freely available to adolescents. Since 2006, preventive fissure sealants have been provided to certain age-groups[33]. The benefits of fissure sealants and topical fluoride have been proven (169, 170). An extension in the use of fissure sealants and introducing the use of topical fluoride in high risk groups would perhaps allow for greater tooth retention and less conservative work hence attenuating oral health inequalities. An increase in the provision of preventive treatments is especially important in Northern Ireland as the

[33] Application of fissure sealants can be used as a primary preventive measure to pits and fissures of first molar teeth in children under the age of 8, second molar teeth in children under the age of 12 and unfilled third molar teeth within 2 years of their eruption. The adolescents within this study would have 13 or 14 years old in 2006 when fissure sealants were allowed under capitation.

population is served by an unfluoridated water supply. Although suggested changes to the SDR have been made here, it was not the intention of this thesis to provide a critique of the SDR.

9.3 Strengths and limitations of the study

Strengths

The strengths of this study lie within the unique dataset which was formed by linking requested variables from two datasets: the NILS (provided by NISRA) and dental registration and treatment reimbursement data (provided by BSO). This provided access to individual data for approximately 28% of the population. This data included not only a wide range of demographics/ socio-demographics but also very detailed information on the use of and registration for dental services. Dental services data was of a longitudinal nature which allowed for a retrospective cohort study across five financial years. Such a detailed study on the use of dental services has never been previously carried out.

A further strength is the approach which has been undertaken within the analyses. The statistical analyses were econometrics based and driven by an economic model.

Limitations

However, this study also had some limitations. Although the linked NILS/ dental dataset contained dental data which was of a longitudinal nature, much of the NILS dataset was of a cross sectional nature. Variables such as occupation and highest educational attainment of HRP were taken from the 2001 census and may have been subject to change across the 2003/04 – 2007/08 study period.

This dataset is missing information on the demand for dental services geographically. It may well be the case that populations within certain areas in Northern Ireland have difficulty in obtaining a dentist. However, a telephone study carried out during this time, in Northern Ireland, found 95% of the 1,000 people questioned had never experienced difficulty in accessing health service dental care (159). The dataset is

also missing information on need for dental services. Within this thesis, disparities in the delivery of dental treatments were found to exist but actual need for treatment was unknown. Need for dental treatment would allow identification of supplier induced demand and inequity in dental treatment provision. It is important to know if in the case of orthodontics, there is over consumption amongst the higher social classes or under consumption amongst the lower social classes. Currently within Northern Ireland a debate is ongoing regarding the use of a validated measure of orthodontic treatment use as part of the basis upon which access to publicly funded care will be permitted. In a context of increasing pressure upon healthcare resources, linking access more explicitly to need may help to make service use more equitable and transparent. Need for services would also allow over consumption/ under consumption of other types of dental treatment in relation to SES.

9.4 Future research

This thesis has highlighted variations in registration for and use of dental care in relation to a range of demographics including socio-demographics. Future research which controls for need or which looks at variations in supply according to dentist characteristics may be appropriate in establishing why variations in registration and use exist. Future research looking at the impact of changes in the SDR upon registration would be useful in determining how successful such amendments are in reducing inequalities in dental registration.

This thesis also highlighted that a large proportion of dental expenditure was on orthodontic treatments. Future research could be directed at deeming how cost effective such measures are. This may be especially useful in the current climate where a coalition government has announced 'efficiency' savings which are directly impacting resources available to the NHS.

Within this thesis, research within California showed socio-economic differentials in oral health may be amenable to change. In order to fully address socio-economic differentials in oral health within the UK, similar data to that used here would be required. Perhaps a good opportunity to collect such data would be alongside the

next national Children's Dental Health Survey, either for the survey population or for a sample of this population.

9.5 Conclusions

This study, through the use of a systematic review, identified a socio-economic gradient in oral health amongst adolescents. An empirical analysis performed on NHS dental data found differences to exist in relation to registration for services and actual services used in terms of both SES and a range of other demographics. Currently dentists have no incentives for how well they care for patients' teeth but rather are rewarded for work carried out. The current system may be widening inequalities in oral health. This study calls for amendments in the current provision of dental services to adolescents within the NHS.

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Appendix

APPENDIX 1 – SYSTEMATIC REVIEW TERMS

Search terms for Medline were as follows:

1. Oral health or Stomatognathic disease or keyword: caries or periodontal disease or orthodontics or mouth trauma or dental trauma or plaque or gingivitis
2. Social class or socioeconomic factors or social welfare or exp poverty or keyword: social or socioeconomic
3. Adolescent or keyword adolescent
4. Great Britain

Search terms for Embase were as follows

1. Social attitude or social welfare or social behaviour or social discrimination or social class or social status or social aspect or social environment or social aspects and related phenomena
2. Adolescent or adolescence
3. Mouth disease
4. United Kingdom

APPENDIX 2 – SYSTEMATIC REVIEW QUALITY ASSESSMENT

Methodological quality

Study Design
Prospective cohort
Cross sectional (Inc longitudinal cross sectional)
Ecological

Recruitment
Full population
Random
Other but well described
Not reported

Response rate
Excellent (>=80%)
Good (60-79%)
Fair (50-59%)
Poor (<50%)
Not reported

Does the study control for age and gender?
Both
Age only
Gender only
Neither

What type of measure was used for the exposure (socio-economic status)?
Individual
Area
School attended

Has a validated measure been used for exposure (socio-economic status)?
Yes
No

Reliability of examiners
Reliability assessed and reported
Reliability assessed, but statistics not reported
Not reported

Adequacy of follow-up (for cohorts only)
Excellent (>=80%)
Good (60-79%)
Fair (50-59%)
Poor (<50%)
Not reported

APPENDIX 3 – NILS VARIABLES

Variable name	Variable description
Household variables (2001 census)	
HH17PLS_COUNT	No. of persons aged 17 and over
HHADCHLDSTR	Household adult and child structure
HHCARS_COUNT	No. of cars in household
HHDEPCHLD_COUNT	Household dependent children
HHFAMTYPE	Household main family type
HHPEOPLE_COUNT	No. of people in household
HRP_AGE	Age of HRP
HRP_COMMBACK	Community background of HRP
HRP_ECACT	Economic activity of HRP
HRP_EDHLQ	Highest level of qualification of HRP
HRP_NSS	NS-SEC (2001) of HRP
HRP_REL	Religion of HRP
HRP_SEX	Sex of HRP
HRP_SOCGRD	Social grade (as used by market industry) of HRP
NS_DEP_EDU	National Statistics deprivation indicator – education
NS_DEP_EMP	National Statistics deprivation indicator – employment
NS_DEP_HEA	National Statistics deprivation indicator – health
NS_DEP_HOUS	National Statistics deprivation indicator – housing
NS_DEP_TEN	National Statistics deprivation indicator – tenure
SOAENUM	Super Output area code
HHOCCSTAT	Occupancy status of household space
HRP_MARSTAT	Marital status of HRP
HHADEMP_COUNT	No. of adults in employment
Individual variables (2001 census)	
AGE	Age
CMMNTY_BCKGRND	Community background
SEX	Sex
GHEALTH	General health
RELP 1-6	Relationship to person 1 – relationship to person 6
1991 census variables	
AGEHH	Age of HRP
MARHH	Marital status of HRP
SEGCES	Socio-economic group of HRP
Status history (April 2001 – March 2008)	
Status history	Six monthly download confirming if individual was living in Northern Ireland or not
Core NILS data	
Gender	Gender

APPENDIX 4 – BSO VARIABLES

Variables requested from BSO for the period 2001/02 – 2007/08

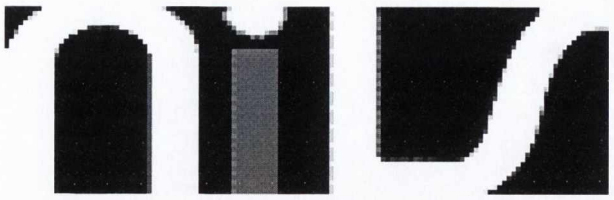
Variables
Total dental expenditure
Registration status with NHS dentist
Distance to closest dentist (April 2008 only)
Distance to most recent dentist used

APPENDIX 5 – COVARIATES FOR DENTAL REGISTRATION ANALYSES - REFERENCE CATEGORIES IN BOLD, POPULATION CHARACTERISTICS IN PARENTHESES (13,564 ADOLESCENTS NILS)

Covariate	Reference category	Subsequent categories				
NS-SEC of HRP	**Professional (29.2%)**	Intermediate (8.0%)	Self-employed (15.9%)	Semi-routine (23.9%)	Routine (16.6%)	Never worked/ long-term unemployed (6.5%)
Highest level of qualification of HRP (education)	**Degree and above (17.0%)**	Two or more a-levels (5.9%)	GCSEs (37.4%)	No qualifications (39.6%)		
Gender	**Male (51.6%)**	Female (48.4%)				
Family structure	**Married (74.1%)**	Co-habiting (3.4%)	Lone parent (22.5%)			
Siblings	**0 (8.2%)**	1 (33.6%)	2 (33.4%)	3 (22.6%)	4 (2.2%)	
Community background	**Catholic (49.7%)**	Protestant (45.9%)	Other (4.4%)			
Distance to closest dentist	**<2 km (66.2%)**	2-<4 km (11.8%)	4-<6 km (9.5%)	6-<8 km (6.0%)	8-<10 km (3.2%)	10-<26 km (3.3%)

APPENDIX 6 – COVARIATES FOR DENTAL TREATMENTS ANALYSES - REFERENCE CATEGORIES IN BOLD, POPULATION CHARACTERISTICS IN PARENTHESES (12,846 ADOLESCENTS NILS)

Covariate	Reference category	Subsequent categories				
NS-SEC of HRP	**Professional (29.8%)**	Intermediate (8.0%)	Self-employed (16.1%)	Semi-routine (23.7%)	Routine (16.2%)	Never worked/ long-term unemployed (6.2%)
Highest level of qualification of HRP (education)	**Degree and above (17.4%)**	Two or more a-levels (6.0%)	GCSEs (37.8%)	No qualifications (38.7%)		
Gender	**Male (51.3%)**	Female (48.7%)				
Family structure	**Married (74.7%)**	Co-habiting (3.2%)	Lone parent (22.0%)			
Siblings	**0 (8.1%)**	1 (34.0%)	2 (33.5%)	3 (22.4%)	4 (2.0%)	
Community background	**Catholic (49.6%)**	Protestant (46.1%)	Other (4.3%)			



NILS & NIMLS APPLICATION FORM

9.5.1.1 The Northern Ireland Statistics and Research Agency (NISRA) is responsible for the Northern Ireland Longitudinal Study (NILS) and the Northern Ireland Mortality Study (NIMS).

9.5.1.2

9.5.1.3 *To access both datasets a number of steps must be completed (see website for more details). The completion of this form is step 4.*

9.5.1.3.1.1

9.5.1.3.1.2 PART A: USER AND STUDY DETAILS

Section A1 Application details

Study Title *(this should be informative, acting as a brief summary for the whole project)*
An exploratory analysis of adolescent dental health and use of dental care services in Northern Ireland

Correspondence address of the Chief Investigator (CI)
Title: Miss
Name: Claire Telford
Position: PhD student
Organisation: **Queen's University Belfast**
Address: Mulhouse Building, Royal Victoria Hospital, Grosvenor road, Belfast
Telephone: 07966 663637
Fax:
Email: ctelford01@qub.ac.uk

Details of applicant(s) *(excluding Chief Investigator)*		
Name	*Organisation*	*Email Address*
Ciaran O'Neill	NUI Galway	Ciaran.oneill@nuigalway.ie

Proposed Start Date	01/04/09	Proposed End Date	01/04/11

9.5.1.4 Section A2 Funding details

It is not necessary to have funding to conduct research with the NILS. However you should tell us if you currently have funding or intend to apply for funding for this project:

Source of funding
Is funding confirmed? Yes – (delete as appropriate)

9.5.1.5 *Section A3 Background and aims of study APPENDIX 7 – RAG FORM*

Project Summary / Abstract
(max 250 words. This will be included in the NILS website if the project is approved)

Those aged 18 and under are in Northern Ireland entitled to have their oral care funded by the health service. This care is typically provided by general dental practitioners – independent contractors – who operate on a for-profit basis. While equal access to funding exists, because care is delivered by independent contractors there is no guarantee of equal access to care in the presence of equal need. Indeed as evidenced by wide variations in registration rates across Northern Ireland, and wide variations in registration rates both linked to deprivation, there is clear evidence of unequal access relative to need. An examination of registration alone however, provides a very incomplete picture of access to services or differences in the intensity or type of services provided. The primary objective of the proposed project is to analyse a dataset formed by linkage of the Northern Ireland Longitudinal Study (NILS) and the reimbursement of general dentist practitioner data collected by the Central Services Agency (CSA). The proposed study will for the first time provide information about the individual user and non-user of publicly funded general dental practitioner services in Northern Ireland. This will be used to examine the relationships between use of services including the type of service used, individual socio-demographic characteristics, access to services and area characteristics associated with use and non-use of services. These analyses should better inform health policy makers, service commissioners and the dental profession about the reasons underlying differential use, its impact and how best it might be overcome. At a time when a new dental contract is under development clearly such an analysis is of significant potential benefit for policy purposes.

The study will be undertaken examining the relationships for NILS members born between 1990/1991 and 1991/92 and still alive in 2007/2008 – i.e. those aged between 17 and 18 in 2008.

Explain the aims of your study
This should describe the specific aims of your projects, including any hypotheses that you hope to test. Include how the NILS is required to address the aims and how the aims relate to Health.

Aims and Objectives:
The aim of this project is to examine and highlight the potential benefits of NILS in answering important and topical health policy questions. The specific objectives are:

i. To link NILS and CSA reimbursement data
ii. To examine variations in utilization of NHS funded general dental practitioner services related inter alia to deprivation and access among adolescents
iii. To examine variations in the intensity and type of service used by adolescents
iv. To examine the registration patterns of adolescents and variations in these related to deprivation and access.

Research Questions:
The proposed project will address the following research question
1. What socio-demographic and access factors are associated with use of publicly funded general dental practitioner services among adolescents?
2. What is the relationship between registration and socio-demographic and access factors among adolescents?

APPENDIX 7 – RAG FORM

9.5.1.5.1 Background to the Study

Please give details of any preliminary or previous work carried out relevant to this application. (This should include a brief summary of what is known to date about your chosen topic and what and how your study contributes to what is known to date)

(a) preliminary related analysis

(b) background literature reviews

(c) previous work

Children and adolescents in Northern Ireland are entitled to publicly funded general dental practitioner care. The Central Service Agency hold data on reimbursement of these services that details exactly what service was provided, to whom, when and where as well as the cost associated the provision of that care. Both the CSA and the NILS dataset incorporate the unique Health & Care identification number and this presents the possibility of easily linking the two datasets.

Northern Ireland has the poorest level of oral health in the United Kingdom. The 2003[1] children's dental health survey demonstrated that amongst 15 year olds, for example, the mean number of teeth affected by obvious decay was 4.4 in Northern Ireland compared with 2.5 and 1.8 in Wales and England respectively. In Northern Ireland while 78% of 15 year old children are affected by decay the figure in England and Wales is lower, at 55% and 65% respectively. A clear relationship between oral health, registration with an NHS dentist and deprivation has also been evidenced (HPSS, 2004).

While individuals aged 18 and under in Northern Ireland are entitled to publicly funded care, care is provided by independent for-profit contractors. The freedom independent contracting status affords general dental practitioners means that they cannot be directed to provide care to particular groups or in particular locations. In consequence while there may be equal access to funding based on need, there does not necessarily exist equal access to care for equal need. Indeed the relationships observed at an area level between deprivation and oral health in Northern Ireland, as well as in registration and utilization, may in part be explained by the differential access to dental services that exists. With financial incentives for general dental practitioners to provide care to private pay patients (in terms of superior remuneration relative to NHS rates), dentists may exhibit a preference to locate in more affluent areas as well as to provide care to more affluent patients.

Some studies in Britain have examined use of dental services[2,3]. No study, however, has examined use within a contained un-fluoridated population where needs in general are likely to be greater and health inequalities more pronounced. This study will address this exploiting the relative ease of access to information and the existence of wide health inequalities to obtain a better understanding of the relationship between oral health, health service use, health service provision and the socio-demographic characteristics of users.

The study will draw on the theory of constrained utility maximisation to inform the construction of models in which use is a function of individual and area based characteristics reflecting the cost (including travel costs) to the individual of visiting the dentist as well as area based measures such as dentists per head of population. Differential consumption of services related to restorative and preventative care as well as recourse to extractions related to socio-economic status and ease of access will also be examined.

APPENDIX 7 – RAG FORM

The proposed study will for the first time provide information about the individual, household and area characteristics associated with registration and use of dental services. This should help guide policies by improving the targeting of interventions aimed at increasing appropriate use of services or by informing the need for further research to discover why the identified groups have lower utilization rates or lower utilization rates for particular services.

1. Steele JL. Children's Health in the United Kingdom, 2003. 2004

2. Todd- Adult dental health in the UK in 1998. London HMSO 1991

3. Attwood D, West P, Blinkhorn AS. Factors associated with the dental visiting habits of adolescents in the west of Scotland. *Community Dental Health* 1993 Dec;**10**(4):365-73

***References if applicable** (Limit of 10)*

9.5.1.6 *Section A4* *Publication and dissemination of NILS data*

Please indicate how you will publicise and disseminate the findings of your proposed study and identify any deadlines
This should include plans for journal papers or conference presentations

Planned outputs and activities:

1. Report on main findings with copies to Chief Dental Officer and Regional Director of Public Health.
2. Conference presentation of main results
3. Journal articles with main substantive results
4. Completion of a PhD thesis.

Expected impact

This research will have an impact on academic researchers, the NILS support team and policy makers. In particular, we expect the following groups to benefit from this research:

- UK based academic researchers (including students) working in social and health related sciences who wish to undertake analyses of health-related data linked to NILS.
- Policy makers concerned with improving the oral health status of young people in Northern Ireland and in reducing health inequalities.
- The wider community of academic and non academic users wishing to undertake NILS-related research, through the increased capacity at NISRA to provide high quality support as a result of these studies.

9.5.1.7

9.5.1.8 PART B: SPECIFYING EXTRACT AND PRACTICAL ARRANGEMENTS

9.5.1.9 ***Section B1 Study population***

Provide a description of the population selected for the study *(For example, all male NILS members enumerated at the 2001 Censuses and aged 16 – 64)*
The study will be undertaken examining the relationships for NILS members born between 1990/1991 (financial years) and 1991/92 and still alive in 2007/2008.

What files will the data be drawn from?
(See the Data Dictionary for a brief description of the data in each of the NILS files)
[You can copy and paste ✓ or X into tables below]

NI Longitudinal Study (NILS)

Census data	**Vital events data**		**Event dates**
2001 (sample members) ✓	Births of NILS Member		from 29 April 2001 to 30 June 2007
	Births to NILS Mothers		from 29 April 2001 to 30 June 2007
2001 (non sample members) ☐	Births to NILS Fathers		from 29 April 2001 to 30 June 2007
	Stillbirths	☐	
	Infant Mortality	☐	from 29 April 2001 to 30 June 2007
1991 (sample members) ☐	Death	☐	from 29 April 2001 to 30 June 2007
	Immigration	☐	from 29 April 2001 to 30 June 2007
1991 (non sample members) ☐	Emigration	☐	from 29 April 2001 to 30 June 2007
	Re-entrants	☐	from 29 April 2001 to 30 June 2007
	Within NI Movers	☐	from 29 April 2001 to 30 June 2007

or

Northern Ireland Mortality Study (NIMS)

Census data	Vital events data		Event dates
All enumerated 2001	Death	☐	from to

9.6 What variables will you need?

9.7 Please list in more detail the variables you need. This section should be completed using the NILS Data Dictionary. If you are not sure of the exact variables you want, give a broad indication of the type of variables you are likely to use and discuss this in more detail with your NILS Support officer. Full details will be required before data extraction can begin. Please add more rows as necessary.

Table name	Name of variable	Description of variable *(for users use only)*
Household		
	HH17PLS_COUNT	
	HHADCHLDSTR	
	HHCARS_COUNT	
	HHDEPCHLD_COUNT	
	HHFAMTYPE	
	HHPEOPLE_COUNT	
	HRP_AGE	
	HRP_COMMBACK	
	HRP_ECACT	
	HRP_EDHLQ	
	HRP_NSS	
	HRP_REL	
	HRP_SEX	
	HRP_SOCGRD	
	NS_DEP_EDU	
	NS_DEP_EMP	
	NS_DEP_HEA	
	NS_DEP_HOUS	
	NS_DEP_TEN	
	SOAENUM	
	HHOCCSTAT	
	HRP_MARSTAT	
	HHADEMP_COUNT	
Person table		
	Age Sex General health Relp 1-6	

Derived variable(s)
You may wish to specify your own derived variables (i.e. variables that do not exist already on the NILS database, which can be created from existing variables). List the input variables to be used in the derivation and, where possible, show how the variable will be derived.

Age- NILS members born between 04/1990 and 03/1991 and 04/1991 and 03/1992 and still alive in 2007/2008
Marital status of mother
Marital status of father
Multiple deprivation measure

9.7.1.1.1 User's own dataset(s)
You may wish to have some of your own data attached to the NILS data, for example area-based characteristics. Please give details below:

CSA dental data

- Registration status with NHS dentist
- Health and care number
- Provision of specific items of service by dentist (see attached list below)
- Total dental expenditure
- Distance to nearest dentist and to dentist used
- Number of dentists operating in super output area

Year	Items of service (from SDR)
All years (2001/02 2002/03 2003/04 2004/05 2005/06 2006/07 2007/08)	0101, 0111,0121, 0201-0206, 0211-0213, 0221 all 14, 15(a), 15(b), 15(c), 16, 17, 18, 2101, 2121, 2201-2205, 2211, 2221, 2301, 2461, 2551-2554, 2561, all 32, 4401-4405, 5301 6341, 6351, 6401, 6501, 6511-6513, 6521-6523,
2001/02	2451-2454
2005/06 – 2007/08	0701

APPENDIX 7 – RAG FORM

In summary: Enter approximate numbers	
Number of variables to be investigated	45 (although all may not be available)
Estimate of number of subjects in study population:	10,000

9.7.1.3 *Section B2* *Service and access arrangements*

Currently, access to the NILS is only available by visiting the NILS safe setting (McAuley House, Belfast) and working alongside a NILS support officer. We do not supply individual-level data for users to analyse themselves outside the safe setting.

9.7.1.3.1 What form analysis will take

Please give a brief description of the type of analyses to be carried-out (e.g. cross-tabulations, time-series analysis etc.

Research Methods:

The process of linking these sensitive datasets is currently ongoing. Although the linkage of NILS and the CSA reimbursement dataset is technically simple, as both contain the unique Health & Care number, the process is likely to be involved: we have to ensure that linkage mechanisms adhere to the principles laid out in the data protection legislation; and the project will have to be submitted for scrutiny by the (local) data custodians, Regional Ethics Committee and Privacy Advisory Committee. Fortunately we can build on the experience of Scotland and Wales (as described above) as precedent and guide for the development of a strict protocol that ensures no leakage of personal information as well as on the work using NILs undertaken by Dr Dermot O'Reilly of Queens University Belfast. All the required encryption and linkage will be carried out by the data providers and NISRA support staff. At no stage will the researchers require or gain access to identifiable census or patient-level data. The final usable datasets with the combined census and health-related data will reside within the safe setting of NISRA, under the usual protocols and restrictions associated with the NILS data. Researchers will have access only to non-disclosive individual-level data, or to generated information which have been suitably aggregated as to render them non-disclosive. It is estimated that this linkage process, including submissions to the Ethics and Privacy Advisory Committees will take approximately two months.

The research project will use the NILS dataset, which consists of approximately 500,000 individuals (28% of the Northern Ireland population), as the basis for defining the sample. Using the CHI number individuals registered and for whom claims data exists will be extracted from CSA data files and matched with NILs data. Utilization will be determined from the CSA database.

Analysis plan:

The study of adolescents will be undertaken Claire Telford a fulltime PhD student in Queens University Belfast supervised by Ciaran O'Neill, Professor Liam Murray and Professor Donald Burden.

The CSA database includes details of the precise treatment delivered, registration status, the area in which the patient resides, the number of dentists per head of population in that area, the distance to the nearest dentist and the distance to the dentist who provided care. The first part of the analyses will be to describe utilization in terms of the number of contacts, the type of contact (restorative, treatment, extraction), the intensity of contact (as measured by the total reimbursement claimed involved) and registration.

The second part of the analyses is essentially an examination of variation in utilization, registration and intensity of utilization across a wide range of demographic, social, socio-economic and geographical variables including measures of access. This will be undertaken using descriptive statistics and multivariate logistic, poisson and linear regression analyses. Logistic regression

analysis will be used to analyse registration status; poisson models will

be used to examine the number of contacts and changes in registration status; linear regression models will be used to examine the intensity of service use. Household and individual based measures of deprivation, such as housing tenure, car availability, social class and educational attainment will be used to indicate socio-economic status, though it is acknowledged that car availability is also an indicator of accessibility and educational attainment may also indicate health kno wledge and attitude. The influence of area-level factors related to access will be of particular interest. This data will be supplied directly by the CSA. NILS members with no link to CSA data will be assumed not to have consulted or have been registered with an NHS dentist during the study period.

What outputs will you need from the Longitudinal Study? *(Please tick those that apply)*					
	SPSS	Stata	Plain text file	Excel	Other (specify):
Crosstabulations	☐	☐	☐	☐	
Aggregated data set of frequency records	☐	✓	☐	☐	
Regression coefficients	☐	☐	☐	☐	

I have read the NILS Licence, Data Disclosure Policy and NILS Security Policy. If approved I agree to sign copies of these documents. *(electronic signatures accepted here)*
Signed: Claire Telford **Ciaran O'Neill**
This form should be emailed to your NILS Support Officer at nils.nisra@dfpni.gov.uk.